FRANCISCAN STUDIES

No. 17 JUNE, 1936

ROGER BACON'S CONTRIBUTION TO KNOWLEDGE

BY

EDWARD LUTZ, O. F. M.

Illustrations by E. Katkoski

In Sanctitate et Doctrina

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"At an incredible distance we might read the tiniest letters" (J. H. Bridges, *Opus Majus*, II, 165).

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ROGER BACON'S
CONTRIBUTION TO KNOWLEDGE

To Professor A. G. Little
and his colleagues of
the British Society of Franciscan Studies
who have accomplished so much
toward making known
the lives and works of
many noble men and women of
the Middle Ages,
this study is respectfully
dedicated.

PREFACE

It would require a whole lifetime for any single investigator to determine exactly how much Friar Roger Bacon has contributed to the learning of his own and subsequent times. Fortunately, however, in recent times numerous scholars have made careful studies of particular phases of this question; and it is possible now to present a summary of their findings. To present such a survey is the purpose of the present study. Though trying to be brief, I have sought to give more than a cursory, encyclopedic treatise which could hardly serve as a satisfactory evaluation of Bacon's achievements. Even so, I feel that I have not done full justice to my subject.

True, one can easily overrate the importance and influence of a universal genius like Roger Bacon who devoted his attention to so many different branches of knowledge. In these days of specialization, we can hardly imagine a savant who holds a position of eminence in a dozen or more sciences at one and the same time. Still, I have made an earnest endeavor to accept only such statements regarding Bacon and his writings as have been made by trustworthy authorities.

Admiration for Bacon's power has not, I hope, made me blind to his weaknesses. By no means do I intend to defend or explain all that he wrote or to approve certain ideas of his which were apparently preconceived, exaggerated, even the result of prejudice. Nor do I wish to extol Bacon as the only one of his day who made any worth while contribution to learning. Undoubtedly like all other groping pathfinders in created knowledge Friar Roger owed much to his able teachers and to the wise men of his own and previous days.

To all who have in any way furthered this attempt of mine, I wish to express my deepest appreciation and for any unintentional mistakes I beg the reader's kind indulgence.

Fr. Edward Lutz, O. F. M.

St. Joseph College, Hinsdale, Ill.,
April 30, 1936

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CHAPTER I

HIS LIFE

Wealth! Oxford! Zeal! From these three sources emerged Roger Bacon, the fascinating genius and acute critic, who grew up with, influenced, and finally saw the decline of one of history's most productive hundred years. To the riches of his parents he owed his schooling and means for research. The University gave him its logical spirit of objectivity, inquiry, and progress. Zeal consumed his soul with religious fervor, even to the extent of following Christ's evangelical counsels, drove his faculties with tireless industry, and made him impatient with those who lagged behind.

Two places claim the honor of his birth, Ilchester of Somersetshire[1] and Todgmore bottom in the parish of Bisley.[2]

Birthplace

According to Professor Little the boy Roger received his elementary education at Saint Mary's Chapel on Stroud River in Hampton parish where for centuries a room bore the title, "Frier Bacon's Study." To prove his point the same chronicler added that the elder William Bacon and his son Roger made a donation to the Abbey of Gaen. Of the immediate family nothing more is known except a remark in 1267 *(Opus Tertium)* that his mother still lived, one brother had also become a scholar, while the eldest had possessed the rich paternal estate until the War of the Barons, when with his sovereign, Richard III, he had been impoverished and banished from the land.[3]

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[1]D. E. Sharp, *Franciscan Philosophy at Oxford* (Oxford: Humphrey Milford, 1930), p. 12.

[2]A. G. Little, "Life and Work," *Roger Bacon Essays* (Oxford: Clarendon Press, 1914), p. 1.

[3]*Ibid.*, p. 2.

When about thirteen Roger, a studious and serious lad, enrolled at Oxford, whither all ambitious English youngsters flocked for a higher education. The reason for this? Famous teachers of the day lectured there: Edmund of Canterbury, Adam Marsh, and especially Robert Grosseteste, the renowned instructor of the Franciscan School. Much like Alexander of Hales at Paris, Grosseteste dominated thought in Great Britain, with this difference, however, that while speculative philosophy appealed more to the former, the latter turned rather to languages, mathematics, and natural science.[4]

Teachers

Eight years under such distinguished masters imprinted a liberal, progressive spirit upon Roger's rugged, selfasserting, somewhat intolerant character. Add to this a vivid imagination, gifted pen, fiery strength of purpose, and he stood out from the crowd as sensational, a coming leader of thought, vain in his strength, exuberant in his praise, pulverizing in his opposition. How to crush an adversary Roger knew, but how to lead the vanquished on the upgrade without undue impetuosity he never learned.

The Master's degree of Oxford had been attained, but the enticing fame of Paris lured him on to greater heights. Alas! how disappointing the leading school of Christendom became on closer acquaintance. Its insistence upon authority and custom ran directly counter to the spirit of Oxford and the ingrained methods of his English lectors. In disgust he regularly absented himself from the lectures of the leading teachers, even William of Auvergne, and Alexander of Hales. The latter's *Summa* he characterized "as heavy as a dray horse." Nevertheless, Roger remained at Paris and in due time obtained the Master of Arts degree also from the Sorbonne.[5]

Paris and Disappointment

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[4]"Life and Writings of Roger Bacon," *Westminster Review*, LXXXI (1864), 5-11.

[5]D. E. Sharp, *op. cit.*, p. 12.

Empowered now to lecture Roger set about showing the university faculty just how a real teacher instructs. He spared neither himself nor them, freely pouring out his energy and his scorn. From sixteen to eighteen hours a day he worked, entirely absorbed in his studies and researches; he gave full vent to his scientific and philological instincts, and noted down some of his experiments, calculations, and conclusions.[6] So unselfish was this zeal for progress that during these years Roger lavishly expended his entire patrimony—at least $90,000 in modern values[7] for books and experimental instruments.

His students, influenced by such heroic measures and by the long hours he devoted toward composing improved elementary treatises for them, became much attached to Roger. But the newly-won fame and especially the biting criticism, often directed at fellow professors, engendered hostility toward the "upstart" from Oxford.

First Books

During these years of feverish activity at Paris several books appeared, one on Physics, another on Metaphysics, a third on the Pseudo-Aristotelian *De Plantis*, a fourth the *Epistola de accidentibus senectutis*[8] which latter he began in 1236. Their pages demonstrate his outstanding intellectual powers and also the immaturity of judgment[9] to be expected from a teacher in his twenties. Hence, later on he often contradicted what he had emphatically propounded in them. Fervent and religious to the core in these and other works, Roger requisitioned all knowledge to the advancement of the Church, the salvation of men, and the glory of God.

Paris, otherwise so distasteful to him, harbored one man after Bacon's own heart, namely the Franciscan, *Petrus*

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[6]T. Witzel, O. F. M., "Roger Bacon," *Catholic Encyclopedia* (New York: Robert Appleton Company, 1912), XIII, 111.

[7]G. G. Coulton, *Medieval Garner* (London: Constable and Company, 1910), p. 342.

[8]A. G. Little, *op. cit.*, p. 6.

[9]T. Witzel, *loc. cit.*

Peregrinus de Maricourt, who so profoundly influenced him, not only for science but also for religion, that Roger entered the rapidly growing brotherhood of Francis of Assisi.[10] Although the date is uncertain—1250 seems to be the most probable—the *Monumenta Franciscana* records his profession on the very day of his entrance.[11] This precipitancy, if such there was, merely furnishes another indication of his generous, impetuous nature. Among the Franciscans Roger appears to have been simply a lay brother, having never, as far as records show, received holy orders.[12]

A Franciscan Friar

Shortly after pronouncing his vows Friar Roger was transferred to Oxford, where with ever increasing renown, he continued his strenuous life of experimental research. From his stay there at this time may date the story of Bacon's famous tower. A great blow now descended on him. His old friend and stabilizer, now Bishop Grosseteste of Lincoln, died in 1253.[13] Subsequently and perhaps consequently his criticism became so sharp and general that no offender, whether layman or cleric, escaped. In alarm his religious superiors ordered him to dull somewhat the edge of his reform weapon;[14] they wisely sought not to disarm but merely to restrain the excessive zeal of their gifted *confrère.* Friar Roger acquiesced.

Obedience likewise sent him to the French capitol about 1256, but the body so long overworked simply broke down. For two years the human dynamo lay silent. Then gradually strength returned and Friar Roger reappeared in his beloved laboratory. New discoveries in optics, the making of lenses, the construction of astronomical tables, the amplifications of his theory on the propagation of force—these proved to the

Sickness

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[10]*Ibid.*

[11]J. S. Brewer, *Monumenta Franciscana* (London: Longman, Brown, Green, Longmans, and Roberts, 1858), p. 533.

[12]A. G. Little, "Life and Work," *Roger Bacon Essays,* p. 1.

[13]"Life and Writings of Roger Bacon," *Westminster Review,* LXXXI (1864), 5-11.

[14]*Ibid.,* p. 18.

world that the "magician" still knew his tricks. Books once more took form from his active brain: *De Speculis, De Mirabili Potestate Artis et Naturae, De Computo Naturali, Metaphysica.*

For recreation Friar Roger instructed poor boys in science, the languages, and mathematics, hoping to form them into a nucleus for a progressive, philosophic-scientific school. Eagerly also he followed current politics and social events in France, England, Africa, Asia Minor, even in far off China and Mongolia.[15] With ill-health conquered, his former versatile energy had returned.

Censorship

Up sprang another obstacle just when he sought to push his educational ideas. A censorship, taken for granted at present, was established, requiring that the writings of all clerics and religious be examined and approved before they were published. Such a condition amounted to a prohibition for Friar Roger, because of the imprudent and inaccurate scientific and doctrinal expressions found so frequently in his pages.[16]

To his credit Roger submitted and restrained his pen until the opportunity of a lifetime presented itself a few years later. Cardinal Guy le Gros de Foulques, Papal Legate in England, heard of Roger's renown, listened attentively to his ideas for bettering conditions, even asked the Friar to commit them to writing that he might consider the program more thoroughly; but Roger did not comply with the request. Ecclesiastical censorship still remained in force and to Roger this appeared an insurmountable barrier.

By 1266 however, the situation had entirely changed. The Cardinal, now Pope Clement IV, the greatest man of his day in all the medieval world, in a letter from Viterbo dated June 22, commanded Friar Roger to send him secretly a written testimony of his scheme. Secretly! Certainly a difficult task

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[15]A. G. Little, "Life and Work," *Roger Bacon Essays*, p. 7.

[16]T. Witzel, O. F. M., "Roger Bacon," *Catholic Encyclopedia*, XIII, 111.

for a mendicant religious. The Holy Father no doubt thought that Roger had already committed his plan to parchment.[17]

Undaunted by the well-nigh superhuman difficulties he began his *Communia Naturalium,* the published result of forty studious and laborious years, exhaustive treatise of the various aspects in nature, as he, better than all others, knew them. But ambitions had outreached resources. Not even Roger Bacon's talent and zeal was able to take the place of necessary time and money; and the required secrecy was a particularly provoking hindrance, since the Father Guardian could not be approached on the matter. How the humiliating begging tours to procure writing materials and stenographic services must have distressed him! Yet in their loyal confidence his friends even pawned and sold their valuables[18] that Roger's monumental work might go on. The original plan had become physically impossible, so in desperation Roger substituted a greatly abridged form of his encyclopedia. Finally after eighteen hectic months the *Opus Majus* in the hands of his faithful pupil, John, began the long journey to Rome[19] and immortality.

Opus Majus

What a precious burden did John of London carry! Its pages held an able analysis of prevalent scientific study, a remarkable program for educational reform, a comprehensive attempt to classify all learning, an able exposition toward a new scientific method.[20] This work justly became outstanding not only in its own age but in all subsequent times as well, particularly by reason of its comparative, progressive language study and its grasp of the physical sciences. Its climax and choicest recommendation lay in his dedication of all knowledge to a supernatural end.

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[17]T. Witzel, *Catholic Encyclopedia,* XIII, 112.
[18]*Ibid.*
[19]A. G. Little, *loc. cit.,* p. 7.
[20]J. M. Stone, *Studies from Court and Cloister* (Saint Louis: B. Herder, 1905), p. 311.

Did Roger now rest? By no means, the battle had just started. Too well he recognized the book's imperfection, a result of the feverish haste of its composition. Yet another reason spurred him onward. The Holy Father had been ailing, and if he died, to whom could our Friar turn?[21] A tense race with death began! And since the insecurity of travel and the manifold duties of the Sovereign Pontiff might also defeat or impede Roger's crusade, he immediately composed and dispatched to the Shepherd of the Eternal City a second work, his *Opus Minus*, a résumé of the larger volume. Somewhat later an *Opus Tertium* treating some ideas more maturely and extensively, and yet a fourth in cipher was sped on the way to Italy.

Death of Clement IV

Unfortunately, however, Clement IV died in 1268, before he could act upon, even if he had opened and read, the enkindling words of Roger's genius and enthusiasm.[22] Those two years of prodigious activity—the *Opus Majus* alone has 350,000 words[23]—stood barren of immediate result. Not crushed by this blow which would have been fatal to most hopes, Friar Roger once more took up his gigantic plan in the *Communia Naturalium*. However, as far as we know, he did not proceed notably towards its completion, for linguistic studies now engrossed him. His Greek and Hebrew grammars, partially come down to us, belong to the years before 1272, when the disappointed Roger began his *Compendium Studii Philosophiae*, a bitter criticism of the state of learning and the corruption in the Church, as he saw it.[24] This attack only added more fuel to the flames of resentment smoldering against him. Five years later came his opponents' opportunity to silence once for all, as they thought, this bothersome and impertinent critic of Oxford.

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[21]W. D. Newbold, *Cipher of Roger Bacon* (Philadelphia: University of Pennsylvania Press, 1928), p. 177.

[22]T. Witzel, *Catholic Encyclopedia*, XIII, 112.

[23]W. R. Newbold, *op. cit.*, p. (xxx).

[24]J. H. Bridges, *Opus Majus* (Oxford: Clarendon Press, 1897), I, xx.

Authorities Criticized

Stephen Tempier, Bishop of Paris and Chancellor of the University, in 1277 with a strong hand repressed the suspected or false ideas that readily sprang up in such an argumentative atmosphere. In answer to this policy there appeared the fatal *Speculum Astronomiae,* an ill-advised criticism of ecclesiastical authority. Who wrote it? Quite probably Roger did. But, even if he was not guilty, the ideas were undeniably his and they were expressed just as he would have written them. Now the long pentup indignation burst upon him.[25] Suspected novelties were easily found among Roger's lines. In vain did he seek by his *De nullitate magiae,* a refutation of the black arts, to dissipate the shadow of heresy and necromancy that tainted his name and fame.[26] Roger stood condemned.

Just at this time the Generals of the Dominican and Franciscan Orders met in Paris to put a stop to the unedifying friction between the two great organizations. One of the first means adopted consisted in the effectual silencing of and the imposition of a salutary penance on the critics concerned.[27] Upon whom would the penalty fall more certainly than upon Roger? He had deeply offended not only the leading Friars Preacher, but had severely castigated his own *confrères* as well.

Accordingly his Minister General, Jerome of Ascoli, condemned Roger and imposed, as penalty, a ten year suspension from the office of teaching.[28] The voice that had striven so mightily for desirable and even imperative reform was silenced. Possibly the friary of Oxford held captive the former Master of Theology. But the charge of any harsh confinement by his superiors has been quite satisfactorily refuted by

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[25]A. G. Little, "Life and Work," *Roger Bacon Essays,* p. 23.
[26]T. Witzel, *Catholic Encyclopedia,* XIII, 111.
[27]A. G. Little, *op. cit.,* p. 26.
[28]*Analecta Franciscana* (Ad Claras Aquas: Ex Typographia Collegii S. Bonaventurae, 1897), III, 360, note 7.

the Abbé Feret's investigations.[29] Such restraints provided punishment enough for Roger's impulsive nature. Then, what special reasons would his English brethren have had to be unduly severe towards the grand old man, now at least sixty-three years of age, very lovable too, in spite of his failings?

None the less, for fifteen years the ideas of the thinker of Oxford were, it is said, effectively withheld from an unappreciative world. Were they? It seems not; for, to these wearisome months of repression might well be assigned the mysterious, remarkably cipher of his, found in the Voynich Manuscript. That this venerable tome came from the pen of Roger, Professor W. R. Newbold has quite conclusively demonstrated by his admirable investigations.[30] Even the autograph, "R. Bacon," has been disclosed with the help of the key from the manuscript's last page. Other intrinsic evidence, as the ink, pigments, type of writing, general appearance of the vellum, all point to the thirteenth century as the date of their origin.[31] And of the outstanding men in those unusual hundred years, who was better fitted by nature and by training to have been the author of the Voynich Manuscript than Friar Roger Bacon,

Voynich Manuscript

Let us reconstruct the situation. Compelled for the most part to remain within the enclosure, occupied with the duties of a lay brother, Roger nevertheless longed for self expression, for the diffusion of those marvels so often referred to before.

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[29]L. Thorndike, "The True Roger Bacon," *American Historical Review*, XXI (1915), 244. The story of the condemnation of Friar Roger to prison as contained in the *Chronicle of the XXIV Generals* is unreliable, as this work was written many years after 1277. Cf. D. Fleming, O. F. M. *Ruggero Bacone E La Scolastica*, (Milano: 1915), p. 16.

[30]W. R. Newbold, *op. cit.*, p. (27).

[31]J. M. Manly, "The most mysterious Manuscript in the world; did Roger Bacon write it and has the key been found," *Harper's Monthly*, CXLIII (1921), 189. I am inclined to the opinion that the cipher was composed at this time because of the Oxford Incident and the comet of the year 1273 together with the Annular Eclipse of 1290. It is possible, however, that these incidents were inserted after their occurrence. Cf. Newbold, *op. cit.*, pp. (133), (125), (121).

He sought and found a way out. A cipher meaningless to the uninitiated formed the vehicle for both concealment and communication. That he had given much study to this art and had rendered himself adept at it his *Letter on the Secret Works of Art and the Nullity of Magic* plainly proved. For in this book seven modes of cipher subterfuge have been enumerated and explained.[32]

Secret Ciphers

Such a method of diffusing knowledge exactly suited Roger's viewpoint and intention. He looked upon a discovery as a special confidence of God[33] and desired to retain the find at least for some time among the learned. "Many are called, but few are chosen for the reception of philosophical truth and likewise for that of scientific truth," he declared in the *Opus Majus*.[34]

Yet another consideration may have some added weight in favor of Bacon's authorship of the cipher; namely, natural modesty which made him averse to having his name publicly linked with some of the discoveries it contained, especially those pertaining to generation. Above all would this have been the case later on when he was a Franciscan vowed to perfect and perpetual chastity, even though there was no lapse into sin.

Being thus disposed and in possession of simple lenses together with the principles of their combination in the form of a microscope and being able to reason scientifically and exactly in astronomy, biology, and medicine, Friar Roger was certainly qualified for the work in mind.

So at his request kind superiors and friends procured parchment for him not to write books, but merely to amuse himself, lest the long hours of comparative inactivity, for one who had been so dynamic, become an insupportable burden. To their knowledge Friar Roger merely drew pictures and

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[32]W. R. Newbold, *Cipher of Roger Bacon*, pp. (24) (25).
[33]*Ibid.*
[34]*Ibid.*

fringed them with unintelligible scribblings. Hence the English Provincial permitted this soothing diversion, since no one could understand the figures anyway. Too true! For over six hundred years from England to Bohemia to Italy they went to baffle the most diligent efforts of investigators toward unraveling their secrets.[35] Only recently, and then solely through the unusual ability and unconquerable pertinacity of Professor Newbold have the odd letters been even partly understood. Their complexity defies adequate brief description. The book written by their discoverer must be carefully read to appreciate his achievements.

Difficulties

Meanwhile the Friar at Oxford committed in part to writing those indescribable sights, of which he confidently wrote to his patron, Clement IV: "And the same for so many other wonders, which I have touched upon in my other works, but neither here nor in my earlier treatises have I been able to explain all."[36] This further elucidation was attempted by his cipher.

In this way the long years of confinement, not without their achievement, came to an end. Jerome of Ascoli, who had become Pope Nicholas IV in 1288, died in 1292; and Raymond of Gaufredi, minister general of the Friars Minor from 1289 to 1295, removed from many, the restrictions placed upon them, among the liberated being Friar Roger. Immediately his keen mind reviewed again for publication those advanced ideas in behalf of which he had borne so much, and his rapidly wielded quill began his unfinished *Compendium Theologiae*.[37]

With a will as brave as of yore, an intellect as bright, and a criticism almost as sharp, the sage of Oxford wrote, but the weakened body could carry on no longer. As the community gathered about the dying man, so a tradition has it,[38] bitter

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[35]*Ibid.*, pp. (29) - (43).

[36]A. G. Little, *Opus Tertium* (Aberdeen: University Press, 1912), p. 18.

[37]A. G. Little, *op. cit.*, p. 28.

[38]T. L. Davis, *Roger Bacon's Letter* (Easton, Pa.: The Chemical Publishing Company, 1913), p. 14.

disappointment at the apparent failure of his well meant efforts, and perhaps also the realization of his own share in that failure wrung these words from his pallid lips: "I repent of having given myself so much trouble to destroy ignorance." Be that as it may, a reliable authority tells us that Friar Roger Bacon was buried among his brethren on the Feast of Saint Barnabas, June 11, 1292, in the Grey Friars' Church at Oxford.[39] There he rests in peace at last to enjoy in paradise, we hope, the reward of labors so sincere.

Death

But turn now from the scene in the ancient friary and behold the motivating force behind his exertions and the distinctive program of attack to which much of Friar Roger's contribution may be attributed.

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[39]A. G. Little, *op. cit.*, p. 28.

CHAPTER II

AIMS AND METHOD

Friar Roger had grand ambitions bounded only by the limits of human ability. Nature's secrets he sought to unravel as much as he could; the educational theory and substance of all the world he sought to reform.[40] If the content of a science could not be improved, then certainly the method of imparting, explaining it could be bettered. And so he proceeded from crude barology to sublimest theology.

Not professing to have developed a distinct experimental technique, Roger, nevertheless, habitually followed a course of action equivalent to it. He studied diligently, meditated upon a topic, experimentally tested it for acceptance or rejection, broadcasted the results.

Learning formed a second nature with Roger, as greed for facts led him to inquire from men and books all they had to offer. From artisan and craftsman, from farmer and housewife, from traveler and soldier, continually he sought bits of information.[41] Scholars of the day he interviewed; the written inheritance of the past he searched for truth, till the knowledge of the West had been assimilated and an acquaintance formed with as much of Saracen, Jewish, and ancient culture as he could lay his hands upon.[42] Shrewdly and open-mindedly Roger thus sought wisdom; common sense told him that no one had a monopoly upon the truth, not even the

His Sources

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[40]R. B. Burke, *Opus Majus of Roger Bacon* (Philadelphia: University of Pennsylvania Press, 1928), II, 787.

[41]J. M. Lenhart, O. M. Cap., "Language Studies in the Franciscan Order," *Franciscan Educational Conference Report,* VI (1924), 76.

[42]G. B. Adams, *Civilization during the Middle Ages* (New York: C. Scribner's Sons, 1922), p. 268.

great Aristotle, and that everyone might know something of which he was ignorant.[43]

Having thus come in contact with a new idea, an unsolved problem, Roger thought it over carefully, studied it from every angle, meditated upon its nature, relations, and possible applications. In considerations such as these his reasonings were often profound, but not in this did his main contribution consist.

Inquisitive Mind

Other scholars thought as deeply or more so than Roger, yet they did not habitually submit their speculations to experiment as he demanded. Not haphazard but exact, mathematical observations alone suited him, in order that each topic might be analyzed and objective reality obtained. In this subjection of speculation to actual life we have Friar Roger's main gift to method. He proclaimed this technique not in so many words but by action.

By its application the weakness of a theory might be revealed, new avenues of study might open to view secrets of nature never imagined before. Certainly this purposive curiosity gave rise to indefinitely large fields of future research and progress. So much in fact did this method of attack yield to Roger that it rendered him too credulous of effects to be obtained from nature, a fault appearing in his medical works. Nevertheless, this very tempering of reasoning by restricting it to objective reality before a conclusion might be drawn cannot be overestimated. This insistence on numerous individual experiments amounted to much more than the single results Roger often obtained.[44] He was never continually up in the clouds of speculation or perpetually with his nose upon the ground of materialism. Well might our Friar be called the first pragmatist, though he built on the firm foundation of the supernatural, Christian religion.

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[43]J. H. Robinson, *History of Modern Europe* (Chicago: Ginn and Company, 1903), p. 273.

[44]A. D. White, *History of Warfare of Science and Theology* (New York: Appleton and Company, 1928), p. 387.

While not the only experimentalist of his time he appears to have been the first to use the term and the first of whom the term might be used in our present-day signification.

For Roger experimental technique constituted a superscience, a "mistress" for all the others, to which they might resort and obtain necessary instruments and on which they might rely for the detection of fraud.[46]

Authority

When observation was impossible or impracticable, Roger necessarily concluded from the authority that appeared best to him. He did not scoff at the past or authority as such. In fact, he had the greatest respect for both, because he drew from them repeatedly and even stated that each generation should be wiser than the preceeding, since it had inherited and could learn from the costly experience of those who had gone before.[47]

Bearing in mind Friar Roger's requirements for trustworthy conclusions; namely, personal knowledge, reasoning, mathematical experimentation, or even a reliable authority, what else could have happened but that the educational defects of his time should have become unbearably provoking. Consequently he ruthlessly exposed and condemned the preponderance of philosophy, the ignorance of the sciences and languages, the disregard for Sacred Scripture, the false method of preaching, and the defective knowledge of even the subjects taught in the schools.[48] Vision of the dire consequences of these shortcomings impelled him to criticism. Nor is it correct to conclude from the wide sweep of his indictment that Roger was a mere destroyer. On the contrary, whenever he demolished, he invariably rebuilt,[49] if he deemed it worth

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[45]L. Thorndike, "The True Roger Bacon," *Philosophical Review*, XXI (1914), 271.

[46]A. G. Little, *Opus Tertium*, pp. 52, 53.

[47]W. L. Courtney, "Roger Bacon," *Fortnightly Review*, LII (1889), p. 258.

[48]A. Zawart, O. M. Cap., "History of Classical Education in the Church," *Franciscan Educational Conference Report*, XI (1928), 104.

[49]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 54.

while, on a grander and more substantial scale than had existed before.

If one would liken an educational system to a lighthouse, then Friar Roger's structure would rest upon the solid concrete foundation of the languages and mathematics,[50] supporting the sturdy stone walls of the sciences whose blocks are individually held together by the mortar and beams of philosophic principles. Surmounting all these auxiliary materials stands the beacon light of theology, tended by trusted guardians, warding men from the rocks of falsehood, and pointing the way to the harbor of Christ's Church and the peace of eternity.

Education

Under the inspiration of this lofty guide and aided by his rather original and independent way, Roger built up an immense store of knowledge. Never satisfied, but always testing and retesting his own work and that of others, ever thirsting and searching for new facts, writing and carefully rewriting his treatises some four or five times, and even then prepared to add or change yet more, freely spending his money and still more liberally his energy, Friar Roger undoubtedly became ideal purposive curiosity personified.[51]

Best of all, Roger's pedagogical method really worked. For he possessed the knack of transmitting the knowledge he had within himself together with that spark of vigor which aroused the will of others to advance. The students sent forth by him from Oxford and from Paris gained renown in various universities of Europe.[52]

As important as his personal contact proved to be, still it fell far short of Roger's ambition, so his pen sought to pass on a portion of his vast erudition to contemporaries and posterity through dozens of books.

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[50]J. E. D. de Montmorency, "Roger Bacon," *Cyclopedia of Education* (New York: Macmillan Company, 1919), I, 316.

[51]F. J. Sheen, *Philosophy of Science* (Milwaukee: Bruce Publishing Company, 1934), p. 91.

[52]J. M. Lenhart, O. M. Cap., *loc. cit.*, pp. 25, 27.

A number of these early became treasured possessions. Some perished during the anti-Catholic riots of the sixteenth century.[53] Others were lost in the darkness of large uncatalogued libraries and were gradually brought to light only as time went on. Up to the second quarter of the twentieth century almost eighty of them had been discovered and were available in manuscript or published form.[54]

Having now become somewhat familiar with Friar Roger's aim, method, and means of communication, we shall endeavor to point out in how far he has enriched a score or more of sciences, basing our survey on the findings of various scholars who have investigated this question.

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[53]A. G. Little, *Roger Bacon Essays*, Appendix, p. 419.
[54]J. M. Stone, *Studies from Court and Cloister*, p. 324.

CHAPTER III

THE SACRED SCIENCES

Possessed of a deeply religious spirit Roger Bacon directed all education toward furthering that Faith which he valued more than life itself. Consistently then, and contrary to the prevailing sentiment of the age, he taught that theology is an independent science to which philosophy and all other branches of learning are subordinate. "I say, therefore, that one science is the mistress of all others; namely theology."[55] Thus the Queen of Knowledge was enthroned by Friar Roger in her rightful place which in Catholic thought at least, she has ever occupied.

Theology

To him the science of God became not mainly speculative, but extremely practical, as he invoked its guidance in the every-day problems of life.[56] If one may judge from the admirable glimpses of his moral theology,[57] the depth of his mysticism,[58] and the clarity of his dogmatic theology[59] afforded by the *Opus Tertium,* then truly later generations suffered a loss when Roger did not develop these more fully.

Especially noteworthy is his principle: "The study of theology longs for all human knowledge" in so far as it seeks to utilize it for the better understanding, the purer love, and the more loyal service of God. In this way Roger demonstrated the unity he beheld in the entire range of man's intellectual

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[55]R. B. Burke, *The Opus Majus of Roger Bacon,* I, 36.
[56]C. R. S. Harris, *Duns Scotus* (Oxford: Clarendon Press, 1927), I, 90.
[57]A. G. Little, *Opus Tertium,* pp. 67, 68.
[58]*Ibid.,* p. 69.
[59]*Ibid.,* pp. 69, 70.

achievements.[60] Logically, therefore, he declared language studies not necessary in themselves but essential only for a correct and comprehensive acquaintance with theology.[61]

For the same reason and because of their cogency for the earthly-minded infidels, Roger enlisted the arguments of philosophy and the conclusions of the natural sciences in the service of apologetics.[62] Mathematics too he placed in line to aid the theologian by the greater clearness a ready knowledge of its terminology produces.[63] Thus equipped, theology can humanly speaking, more readily, lead men to God.

Sacred Scripture

So much for the auxiliaries; but now let us see how thoroughly Roger recognized the mainstay of theology; namely, Holy Scripture. His estimate of it may be judged from the words: "There is only one perfect wisdom which is contained in the Scriptures and is to be unfolded by canon law and philosophy."[64] In Roger's time the verbal condition and consequently also the explanation of the Sacred Books was chaotic. Everyone, or almost everyone it seemed to him, changed the reading as he chose, and as it appeared best to his judgment, or worse yet, even to suit a purpose.[65] This condition could not be tolerated, so he strove to remedy the situation. The masterly and intelligent way he went about correcting the abuse proved conclusively that Roger possessed a marvelously clear grasp of the entire subject of biblical revision more than three centuries before its eventual accomplishment.[66]

First of all Friar Roger begged Pope Clement IV sternly to prohibit private attempts at correcting the Bible[67] and of-

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[60]H. Holzapfel, O. F. M., *Handbuch der Geschichte des Franziskanerordens* (Freiburg im Breisgau: Herdersche Verlagshandlung, 1909), p. 270.
[61]A. Zawart, O. M. Cap., *loc. cit.*, p. 103.
[62]R. B. Burke, *op. cit.*, I, 71-103.
[63]*Ibid.*, I, 195.
[64]*Ibid.*, I, 56.
[65]J. M. Lenhart, *loc. cit.*, pp. 44, 45.
[66]F. A. Gasquet, O. S. B., "Roger Bacon and the Latin Vulgate," *Roger Bacon Essays*, p. 99.
[67]F. A. Gasquet, O. S. B., *op. cit.*, p. 96.

ficially to declare the original Vulgate of Saint Jerome the sole authentic text.[68] Toward obtaining the original, skillful and learned men must search diligently for the most ancient manuscripts. If these cannot be found, then substitute the Greek and Hebrew versions. In regard to the latter assiduous care must be exercised to distinguish Saint Jerome's work from its later badly mutilated transcriptions. Thus, to discern the genuine Latin text, the grammar and syntax of that language must be perfectly understood[69] and the various readings of the Fathers, the history of the versions, even the very origins of textual corruption must be carefully examined.[70] Subsequent experience has proved that these suggestions of Friar Roger formed the only possible course for restoring the true reading of the Book of Books.

Exegetical Studies

Upon scriptural exegetes who would interpret the real meaning of the text these studies, according to Roger, were obligatory: history, both ecclesiastical and political; the biblical languages, Hebrew, Armaic, and Greek; the archaeology and geography of cities and nations mentioned in Holy Writ. Further to enhance their explanations let these students utilize such branches as mathematics, which will enable them more fully to comprehend the dimensions and construction of, let us say, the ark, the tabernacle, the temple. With all these subjects forming a background, expositors may proceed with some hope of success toward building up a reliable mystic sense.[71]

Monumental, indeed, are these guiding principles of Roger Bacon. Following them the Council of Trent declared the Vulgate of Saint Jerome, the sole authentic text of the Bible.[72] To study scriptural problems the Holy See created in the be-

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[68]F. A. Gasquet, O. S. B., "English Biblical Criticism in the Thirteenth Century," *Dublin Review*, CXXIII (1898), 7.

[69]B. Cuneo, O. F. M., "Biblical Scholars in the Franciscan Order," *Franciscan Educational Conference Report*, VII (1925), 39, 40.

[70]J. M. Lenhart, O. Cap., *loc. cit.*, pp. 44, 45.

[71]B. Cuneo, O. F. M., *loc. cit.*, p. 67; R. B. Burke, *op. cit.*, I, 195.

[72]B. Cuneo, O. F. M., *loc. cit.*, p. 52.

ginning of the present century the Biblical Commission composed of learned men especially fitted for this office.[73] Lest the exact wording of the Sacred Books be falsified, Holy Mother Church in the course of time issued the prohibitions of Canon Law against any private tampering with the text.[74] Truly, in the field of scriptural revision and textual criticism Friar Roger occupies a class all by himself. His theory has been developed into the accepted official practice of today.

Canon Law

With the trail marked for the restoration of the true Word of God to the Church, Roger next sought to free Her legal procedure from the domination of the civil law. Unfortunately canonists had injected the spirit of the civil court into their decisions pertaining to ecclesiastical matters.[75] To this unsatisfactory practice Roger attributed much of the judicial confusion during the thirteenth century.[76] Hence with all his vehement oratory he implored the Sovereign Pontiff to tear such unbearable chains asunder by entirely re-organizing Church Law. In its proper sphere, Friar Roger contended, sacred jurisprudence must be unfettered. Its firm and independent foundation should be, he continued, the Sacred Scriptures and the teaching of the Fathers in the East and West. If this were done, the Church's legislation would lose its secular character and its laws would really become, as they had been intended, a help towards peace and not a menace to security.[77]

Partly perhaps, to this agitation of Bacon we may trace the Church's formulation of Her own distinct code of law in after years. He deserves great credit at least for detecting the fetters binding the ecclesiastical courts and suggesting an expedient against the danger of incorporating the spirit and

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[73]F. A. Gasquet, O. S. B., "Roger Bacon and the Latin Vulgate," *Roger Bacon Essays*, p. 96.

[74]F. A. Gasquet, O. S. B., *op. cit.*, p. 96.

[75]H. Felder, O. M. Cap., *Studien im Franziskanerorden* (Freiburg im Breisgau: Herdersche Verlagshandlung, 1904), p. 389.

[76]B. Cuneo, O. F. M., *loc. cit.*, p. 67.

[77]H. Felder, O. M. Cap., *op. cit.*, p. 389.

principles of secular tribunals, with their emphasis upon the material, into the judicial life of the Church, which predominates in the spiritual. With the same energy and ability Friar Roger turned to the needs of homiletics, this religious, educational agency, so necessary for the Church's offense and defense, so indispensable for maintaining Catholic life at home and for enlarging Her conquests in heathen territory. Sermons in his day were for the most part unworthy of the name, and preachers ignored the main purpose of sacred eloquence. Instead clerics delivered vain productions very complicated in structure and full of meaningless bombast. They merely paraded their false, perverted learning and cared not a whit for practical and beneficial effects upon the hearer.[78]

Homiletics

Such inefficiency could not have escaped his vigilant zeal, so Roger placed himself among the vanguard of its critics and caustically denounced this degeneracy in pulpit oratory. Especially the notorious, multiple divisions, unjustifiable scriptural citations, and useless word quibbles[79] provoked his ire. These, he thundered, were entirely derogatory to the exalted position of the speaker utilizing one of the principle means in Christ's Church for the betterment of morals. Preachers must seek not their own glory but endeavor to instruct and confirm their audiences in virtue. Let them guide and incite the people to a truly Christian life by well directed rhetoric, powerful in persuasion, replete with true learning, enlivened by the compelling fire of eloquence. Arguments must be based on Sacred Scripture and patristic tradition, couched in a diction understandable to all, and with an eye to practical utility.[80]

Thus to Friar Roger sacred eloquence became both a science and an art directed to a sublime and noble end, human

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[78]H. Felder, O. M. Cap., *Ideals of Saint Francis* (Chicago: Benziger Brothers, 1925), p. 342.

[79]H. Holzapfel, O. F. M., *Handbuch der Geschichte des Franziskanerordens*, p. 270.

[80]H. Felder, O. M. Cap., *op. cit.*, p. 492.

salvation. By his incisive condemnation of existing abuses, by the weight of his fame, and especially through the sound homiletic principles he drew up, Friar Roger very noticeably contributed to the great revival of efficient preaching by the Mendicant Orders in the thirteenth century.[81]

[81]H. Felder, O. M. Cap., *op. cit.*, p. 342.

CHAPTER IV

PHILOSOPHY

Theology's handmaid, philosophy, Friar Roger by no means neglected; for he lived and died a thorough-going medieval schoolman. It was only against Scholasticism wandering astray that he railed. His extremely practical nature simply revolted at mere speculation. Verification of principles by experiment and actual observation constituted his battle cry.[82] To this acid test Roger subjected his own deductions, as he wrote to Pope Clement IV: "Since it behooves that all things which I have written be verified by instruments and by demonstrations, it shall so be done, whenever it will please the will of Your Holiness."[83]

Pagan Philosophy and Revelation

Friar Roger heartily agreed with fellow schoolmen that the incomplete pagan philosophy needed theology developed from revelation to form a compact system, but he disagreed when he held the basis of human knowledge to be experience and experiment. By this happy combination he avoided their error of depending too much upon authority and the mistake of later non-scholastics of leaning too heavily upon sense impressions.[84]

For a more perfect philosophy he demanded the original Aristotle purged of all later corruptions by heathenism and Mohammed's followers.[85] Rather begin all over again he declared and learn from lengthy experimentation than build a

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[82]E. Stateczny, O. F. M., *Compendium Historiae Philosophiae* (Romae: Ex Typographia Sallustiana, 1898), p. 391.

[83]A. G. Little, *Opus Tertium*, p. 44.

[84]D. E. Sharp, "Roger Bacon," *Encyclopedia Britannica* (New York: Encyclopedia Britannica Inc., 1929), II, 890.

[85]H. Felder, O. M. Cap., *Ideals of Saint Francis*, p. 273.

system upon the insecure foundation furnished by poisoned Arabic translations of the Stagirite.[86]

Standard of Human Authority

Roger accepted human authority at its real worth; a human statement was as solid as its arguments, a theory had to be proved, and therefore, human authority was secondary to observation as a source of truth.[87] With such a standard his severe criticism of the weak points in Scholasticism inevitably followed. Fruitlessly he endeavored to stay its degeneration into barren speculation and over-emphasis upon authority. As an antidote against the former Friar Roger sought to popularize an independent study of Nature.[88] To overcome the blighting effect of the latter he repeatedly warned against blind adherence to unworthy authority, undue influence of custom and popular prejudice, crafty concealment of ignorance by an ostentatious display of wordy knowledge.[89]

His insistence upon freedom of inquiry regardless of the common and growing hero worship of the schools formed one of his choicest contributions to philosophy and can hardly be overestimated, because without this liberty all progress must cease.[90]

Instead of excessively adhering to untried opinions, even when voiced by celebrated men, Roger pleaded that philosophers should proceed from the known to the unknown whenever possible by building upon the findings of the natural sciences. Thus, the abstract would be derived from the concrete.[91] General principles can be learned in this way alone. But that

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[86]J. H. Robinson, *History of Western Europe*, p. 273.

[87]H. Felder, O. M. Cap., *Studien im Franziskanerorden*, p. 489.

[88]E. Hutton, *Franciscans in England* (London: Constable & Company Ltd., 1926), p. 153.

[89]A. Zawart, O. M. Cap., *loc. cit.*, p. 104.

[90]"The Philosophy of Roger Bacon," *Westminster Review*, CXXXI (1864), 514.

[91]C. Dittmeier, O. M. C., "The Teaching of Ontology," *Franciscan Educational Conference Report*, XII (1930), 188.

Research Facilities

was not all. Keep abreast of the times, he continued, follow the developing thought of each year with its new discoveries in every line.[92] For this purpose he advocated research laboratories, necessary instruments, and copious funds in the form of endowments and foundations for each important school for the purpose of paving the way for and checking up on all speculation.[93]

If Friar Roger had done naught else but analyse the weakness and trend of Scholasticism, refuse to accept a false Aristotle, correctly gauge human authority, and propose such a detailed plan of fruitful action, he would at least in the field of philosophy have merited immortal fame. Broadly speaking, his system of arriving at general principles and keeping them up to date has not been greatly improved upon in the last six hundred years. However, lest this angle of his importance be exaggerated, we add that some of Roger's ideas arose from the Franciscan Oxford tradition.[94] The credit, nevertheless, for braving public opinion and developing a definite program certainly belongs to Roger.

Besides this his criticism of the weak spots in the otherwise magnificent system of Saint Thomas formed the starting points for the two later eminent schools of Franciscan thought; namely, those of Duns Scotus and William Occam, and thus, it seems, of all that was worth while in subsequent medieval philosophic activity.[95]

His treatment of the plurality of forms in the human species gave Scotus the start for his theory on this subject, a theory that still holds its own among all other explanations. "Forms are diverse in a specific nature *secundum se*,"[96] wrote

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[92]E. Dorzweiler, O. M. Cap., "How can we vitalize our course of Philosophy and make it meet contemporary modes of thought?" *Franciscan Educational Conference Report*, XII (1930), 52.

[93]F. A. Gasquet, O. S. B., "English Scholarship in the Thirteenth Century," *Dublin Review*, CXXIII (123), 364.

[94]D. E. Sharp, *Franciscan Philosophy at Oxford*, pp. 118, 119.

[95]H. Rashdall, *Compendium Studii Theologiae* (Aberdoniae: Typis Academiis, 1911), pp. 20-24.

[96]D. E. Sharp, *op. cit.*, p. 134.

Roger. Most significant, however, became his principle of individuation which broke away from the trends of Aristotelianism and restored to the individual person the full value of will and intellect.[97] "One individual is worth more than all the universals in the world." "God has not created the world for the sake of the universal man, but for the sake of individual persons."[98] "The will cannot be forced even though it may be urged by the bodily senses and the very powers of heaven."[99] On these momentous decisions hinge the power of the single intellect, the spontaneity of the act of willing, the more readily explainable concept of personality, the moral value of the human being,[100] all superbly developed later by Duns Scotus.

Influence on Scotus

Roger's trilogy of conclusions: the name signifies primarily the concrete, individual, actually present thing, which is discernible by the senses, and matter is nobler than the form, gave the first impetus to Occam, who later erroneously denied the intelligible and sensible species. Likewise Roger's careful experiments and deductions from animal behavior induced William to give this phase of investigation such an important place in his psychology.[101]

Influence on Occam

In his Theory of Species or Forms Roger made a further notable attempt at explaining the phenomena of qualitative change in the world. Although he failed to solve the difficulty of interaction, he clarified somewhat the meaning and function of form and matter and the details in the process of assimilation—all significant for optics, physics, and psychology. This lofty speculation, the result of much patient, clear, and

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[97]E. Longpré, O. F. M., "The Psychology of Duns Scotus and its Modernity," *Franciscan Educational Conference Report*, XII (1931), 63.
[98]J. W. Thompson, *The Middle Ages* (New York: Alfred A. Knopf, 1931), p. 776.
[99]A. G. Little, *Opus Tertium*, p. 4.
[100]E. Longpré, O. F. M., *loc. cit.*, p. 63.
[101]H. Rashdall, *Compendium Studii Theologiae*, pp. 22, 23.

deep thought, reveals a Roger Bacon seldom seen before in his abstraction from concrete applications.[102]

New ideas sprang out of his study on generation. By changing a few technical terms in his chapter on the propagation of force, we find that a great deal is anticipated concerning present physical theories.[103] Due to Roger's insistence upon observation his cosmology became the most complete and exact the Western World produced up to his own time[104] and for a long time afterward. In moral philosophy Roger constructed the first comparative study of the world's religions,[105] and he springs a surprise on us by his comprehensive plan for an old age pension and a regulation of business, both under the control of the civil government.[106]

The history of philosophy[107] Roger enriched with his accounts of contemporaries, the universities of Oxford and Paris, the dates for the introduction of Aristotle's various works and especially by his clear grasp[108] of the unity in human events. Certainly Friar Roger's picture of medieval civilization ranks among the best that have come down to us.[109]

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[102]H. C. Longwell, *Theory of Mind of Roger Bacon* (Strassburg: University Press, 1908), pp. 7-45.
[103]D. E. Sharp, *Franciscan Phillosophy at Oxford*, pp. 124, 125.
[104]*Ibid.*, p. 153.
[105]R. B. Burke, *The Opus Majus of Roger Bacon*, II, 787, 788.
[106]*Ibid.*, II, 661.
[107]H. Rashdall, *Compendium Studii Theologiae*, p. 23.
[108]D. E. Sharp, "Roger Bacon," *Encyclopedia Britannica*, II, 890.
[109]L. Thorndike, *A History of Magic and Experimental Science* (New York: Macmillan Company, 1923), II, 649.

CHAPTER V

LANGUAGES

In Friar Roger's scheme of education the first essential consisted of a knowledge of languages, not Latin alone, but Greek, Hebrew, Aramaic, and Arabic as well. This plank of his platform he insistently and vehemently advocated in season and out of season. His principal motivating reasons were these: the serious study of languages affords an excellent training for the adolescent mind; proficiency in them opens wide the riches of ancient thought and Saracen erudition;[110] they are needed to convert non-Catholics to the Fold; they are useful for foreign trade, successful diplomacy, and pleasant travel.[111]

Intensity of Study

Neither did a mere smattering knowledge suffice. To know a language in Roger's parlance meant accurately to understand its grammar and genius. Well aware of the great schoolmen's weakness in all foreign tongues except the Latin, the spokesman of Oxford reproached them severely for this deficiency. In one respect, however, Roger, unlike the unbalanced devotees of the Renaissance, fortunately remained very much a man of his own time; he insisted upon languages not for their own sake but because of their subordinate relation to the higher studies.[112]

As the next logical step he demanded the elimination of the faulty and inefficient grammars of his day. To displace them he composed scientific elementary grammars in the lan-

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[110]J. E. D. de Montmorency, "Roger Bacon," *Cyclopedia of Education*, I, 316.

[111]A. G. Little, *Studies in English Franciscan History* (Manchester: University Press, 1917), p. 210.

guages he desired men to master.[113] Aided by such practical text books scholars could really become adept in the characteristic systems of inflection and syntax and reach the wellsprings of sacred truth by their knowledge of the original tongues used in Holy Scripture, or they might draw at their pleasure from the philosophic and scientific works of Greek and Arab.[114] All this existed not in mere vain theory, for Roger's students gained renown throughout Europe by their linguistic ability; and his grammatical treatises circulated steadily through the western lands until the religious revolution of the sixteenth century.[115]

Latin

Belonging as he did in time at least to the Middle Ages, Latin formed Friar Roger's ordinary vehicle for didactic expression, and enthusiasm for its study urged him to a thorough acquaintance with all obtainable Latin authors. In this connection his quest brought to light in 1266 or 1267 the *Dialogues* of Seneca which turned out to be the oldest manuscript in the family of *deteriores* found up to that time or since. By it we are brought three to six hundred years nearer to the time of Seneca in the search for his exact words. Thus, besides his use of the *Dialogues* for moral philosophy, Roger became the first medieval scholar to possess them and an important witness for their genuineness.[116]

Besides this find his outspoken defense of the ancient classics created such a friendly atmosphere in England that Oxford managed to carry these subjects through the fourteenth century down to the Renaissance in spite of prevailing

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[112]J. E. D. de Montmorency, *loc. cit.*, I, 316. Cf. also F. B. Gruen, O. F. M., *English Grammar in American High Schools since 1900* (Washington, D. C.: The Catholic University of America, 1934), p. 22.

[113]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 54.

[114]*Ibid.*, p. 10.

[115]J. E. D. de Montmorency, *loc. cit.*, I, 316.

[116]C. H. Beeson, "Roger Bacon and the Dialogues of Seneca," *Manly Anniversary Studies in Language and Literature* (Chicago: University of Chicago Press, 1923) p. 248.

over-emphasis on philosophy.[117] This regard, however, did not blind him to their insufficiency for attaining divine and human wisdom in foreign tongues,[118] nor to the imperfection of their translations or their immense debt to other languages for more expressive technical and even common-place words.[119]

Greek

Under Friar Roger's guidance the study of Greek in the West took on new life. Having so thoroughly mastered the language as to make himself its ablest occidental scholar,[120] he carefully considered its hitherto published grammars with an eye to their improvement. Then Roger set to work and produced the first, strictly speaking, scientific, elementary grammar of the western world.[121] In form it followed the catechetical method[122] and introduced to Latin civilization the pronunciation known as Itacism three hundred years before Reuchlin again brought it to the notice of the western nations.[123] According to an excellent authority this method dates back to the Alexandrian times and was used even by the Apostles.[124] A comparison between Roger's grammar and a later one composed by Eberhard of Bethume showed the merits of the former to have been far superior to the latter.[125] Still not content Friar Roger planned and perhaps did construct an elaborate Greek grammar for advanced students, but so far the volume has not been found.[126]

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[117]A. Neufeld, O. M. Cap., "The Value of the Classics," *Franciscan Educational Conference Report*, XI (1928), 105.

[118]R. B. Burke, *The Opus Majus of Roger Bacon*, I, 75.

[119]R. B. Burke, *op. cit.*, I, 98.

[120]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 54.

[121]E. Nolan & S. A. Hirsch, *The Greek Grammar of Roger Bacon*, (Cambridge: University Press, 1902), p. lix.

[122]C. H. Haskins, *Studies in Medieval Culture* (Oxford: Clarendon Press, 1929), p. 83.

[123]E. Nolan & S. A. Hirsch, *op. cit.*, p. xx.

[124]B. Cuneo, O. F. M., *loc. cit.*, p. 133.

[125]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 54.

[126]E. Nolan, & S. A. Hirsch, *op. cit.*, p. xxxv.

Hebrew

Exceedingly dear to the heart of Roger did the pursuit of Hebrew become, because of its use by the Sacred Writers of old in conveying to us much of the revealed word of God. Hence, back to the Friary of Oxford we must go for the beginning of this study in Europe.[127] Before Roger, there is no direct historical evidence of Hebrew scholarship on the continent.[128]

Many were the years Roger labored to perfect himself in its speech, and if one may judge from his words, he must have been almost as proficient in Hebrew as in Latin and Greek.[129] Though this may appear somewhat exaggerated, at the very least Roger could and often did refer to the original text for the correct meaning of doubtful words, whenever the Latin version of the Sacred Scriptures seemed faulty to him.[130] This regard for the language of the Jews yearly grew stronger within him because its mystic meaning appealed strongly to his nature.[131]

Being entirely too altruistic to keep such a good thing to himself he composed a scientific, elementary grammar that all who wished might draw first hand from the rich stores of Jewish literature.[132] This work proclaimed Friar Roger the initial non-oriental Hebrew grammarian in Latin Christendom.[133] Only a fraction of this book has so far been discovered, but judging from the remarkable ability of his pupils, who disputed with the Rabbis themselves in the various cities of Europe and appealed as a final resort to the Hebrew text in support of their contentions, Roger's method must have been efficient to the highest degree.[134]

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[127]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 27.
[128]E. Nolan & S. A. Hirsch, *op. cit.*, p. lxiii.
[129]S. A. Hirsch, *A Book of Essays* (London: Macmillan & Co., Ltd., 1905), p. 71.
[130]E. Nolan & S. A. Hirsch, *op. cit.*, p. 12.
[131]*Ibid.*, pp. 32, 36, 37.
[132]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 27.
[133]M. Cohen, "Roger Bacon," *Jewish Encyclopedia* (New York: Macmillan Company, 1919), I, 316.
[134]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 127.

Due largely to his influence the Ecumenical Council of Vienne in 1311 made provisions for the study of Hebrew, hitherto almost entirely neglected at the schools, by establishing chairs for the study of the language in the universities of Oxford, Bologna, Salamanca, and Rome.[135] From then on, of course, the position of Hebrew in the western Christian world remained secure.

Arabic and Chaldaic

Consistently with his program of education Friar Roger devoted himself also to the acquisition of the Arabic and Chaldaic tongues. In this case, however, motives were different; these languages he cultivated solely for scientific purposes, and bountiful, indeed, the yield proved to be.

If one may conclude from his usual habit of insisting upon a personal, scientific, grammatical knowledge, then it seems he must have possessed such a knowledge of these dialects. Otherwise Friar Roger could hardly have derived so much as he did from Saracen sources,[137] as his works sufficiently bear out.

Again, that all interested scholars might share his gain, in his *Opus Tertium* he earnestly urged Pope Clement IV to promote study of these languages in European universities.[138] But the death of the Supreme Pontiff sounded the funeral knell also to this plan. Credit for farsightedness goes to Roger nevertheless.

English

Still another feather seems to belong in Roger's cap. According to an author of the last century, who appears to write authoritatively, Friar Roger Bacon, more than any other, is the one to whom the first additions and developments from the old Anglo-Saxon into modern English must be attributed. His claim for fame in this matter rests on his copious intro-

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[135] J. E. D. de Montmorency, "Roger Bacon," *Cyclopedia of Education*, I, 316.
[136] J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 75.
[137] *Ibid.*, p. 44.
[138] *Ibid.*, p. 75.

duction of Latin vocables into the vernacular of the thirteenth century, and he used them, furthermore, in the same signification they have today.[139]

Although Friar Roger had become outstanding in half a dozen particular languages, in philology he held a pre-eminent position, as many erudite pages of his hastily written *Opus Majus* proclaim.[140] In this field his comprehensive mind had a fit sphere of action, and his accomplishments deserve a great deal more recognition and respect than they have received;[141] for if Roger did not develop into the first scientific philologist, his contribution furnished at least an important step in the growth of philology and singled him out as the precursor of this science which fully emerged during the Renaissance.[142] Considering the means at his disposal he certainly achieved magnificent results, because he inaugurated an independent and systematic search into the organic and fundamental bases of the world's languages[143] by investigating the causes of language formation and the physiological processes necessary for speech.[144] From these discoveries he evolved the scientific kinship of tongues, something utterly unknown before him, also the grouping of dialects; and he even sought to reconstruct the original language spoken by man. And all this almost seven centuries ago!

First Scientific Philologist

More startling yet, Roger endeavored to invent or prove the existence of a universal grammar with national tongues differing only accidentally.[145] His *Summa Grammatica*, as yet

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[139]S. Neil, *Epoch Men and the Results of their Lives* (Edinburgh: William P. Nimmo, 1871), pp. 108, 109.

[140]R. B. Burke, *The Opus Majus of Roger Bacon*, I, 75 *et seq.*

[141]J. H. Bridges, *Bacon's Life and Work* (London: H. G. Jones, 1914), pp. 62-73.

[142]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 127.

[143]S. A. Hirsch, "Roger Bacon and Philology," *Roger Bacon Essays*, p. 103.

[144]J. M. Lenhart, O. M. Cap., *loc. cit.*, p. 127.

[145]J. E. D. de Montmorency, "Roger Bacon," *Cyclopedia of Education*, I, 317.

unedited, may possibly contain this highly ambitious attempt.[146]

Much of this knowledge, no doubt, our Friar obtained from his *confrère,* William Rubruk, and the other Franciscan missionaries, who had traveled so extensively in the East,[147] because in philology as in all other sciences he drew from objective, concrete proof and first hand authorities whenever possible. Nevertheless, despite his debt to these apostolic men, the credit for creating this organic body of knowledge with its unprecedented conclusions and lofty aspirations once again belongs to the leader of England's university.

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[146]A. G. Little, *Studies in English Franciscan History,* p. 213.
[147]J. M. Lenhart, O. M. Cap., *loc. cit.,* p. 127.

CHAPTER VI

MATHEMATICS

Beside the knowledge of languages and on a par with it Friar Roger placed mathematics. These two branches constituted the gate of the natural sciences, the alphabet for philosophy, and the key to theology in as far as they opened wide the storehouses of past learning and intensified its understanding.[148] As his guide Roger formulated this significant principle: "All natural philosophy is ultimately mathematical."[149] Undoubtedly he thus took a stand entirely opposed to the general estimate and trend of his time regarding mathematics and, to be frank, a stand only too recently admitted and followed by the majority of scholars.

Abstract and Applied Mathematics

Imbued with such sympathy for his subject Roger assiduously fitted himself with the knowledge of every standard author available to imbibe the mathematical lore of all preceeding time.[150] More amazing still he tried to solve almost every problem they presented in his own original way.[151] What an enthusiasm such industry must have required, especially when we consider the voluminous works of his predecessors? All this, however, was merely preparatory. To Roger abstract learning formed but the stepping stone to its practical application and use for the benefit of man.[152] Truly in this last respect he certainly had no equal until the nineteenth century.

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[148]D. E. Smith, "The Place of Roger Bacon in the History of Mathematics," *Roger Bacon Essays*, p. 176.

[149]J. H. Bridges, *Opus Majus of Roger Bacon*, I, 66.

[150]D. E. Smith, *op. cit.*, p. 183.

[151]J. M. Lenhart, O. M. Cap., *Science in the Franciscan Order (Franciscan Studies*, No. 1, New York: Joseph F. Wagner, Inc., 1924), p. 15.

[152]J. H. Bridges, *op. cit.*, I, p. lix.

Hence he constructed tables for astronomy and for simple mensuration, devised useful alloys and coinage, and even bettered the mathematical side of business partnerships and commercial relations by improved systems of book-keeping.[153] The science of physics likewise finds itself much indebted to Roger for the reliable method with which he applied mathematics on an extensive scale to the solution of its problems.[154]

In fact, the research work of the present age is indebted for the cause and beginning of its productivity to Roger's elaboration of the principle in the fourth and fifth sections of his *Opus Majus,* that force is exactly determined according to a mathematical law and is multiplied so uniformly and regularly in space and time that it can be expressed by lines, angles, and figures.[155] With such an orderly and trustworthy procedure experiments can be accurately checked, past success sufficiently understood, its future probability judged merely from a mass of figures on paper without the futile expense of time, money and even life in useless trials and models. After Friar Roger had enunciated his conclusion, mathematics became the criterion of conscious, material progress by which men can know in advance whether or not success may or will crown their efforts towards a better engine, a stronger cloth, a more efficient gargle.

Perhaps just as much did he contribute to the science of exactly reckoning time by his treatise entitled *Computus,* which is exemplary in the extreme as a careful and objective mathematical investigation replete with historical and scientific data.[156] Prompted by these researches Roger gradually became aware of the errors in the old Julian calendar. So he prepared a rectified one in 1263[157] and suggested the

Chronology

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[153]J. H. Bridges, *op. cit.,* I, lvii.

[154]J. M. Lenhart, O. M. Cap., *op. cit.,* p. 59.

[155]A. G. Little, *Studies in English Franciscan History,* p. 195.

[156]A. G. Little, "Roger Bacon," *Proceedings of the British Academy,* (London, 1928), pp. 279-280.

[157]"Roger Bacon," *New International Encyclopedia* (New York: Dodd, Mead and Company, 1930), II, 508.

useful expedient of omitting one day in 125 years to maintain a highly accurate time basis.[158] His efforts, however, were ignored for more than three hundred years, until finally at third hand Roger's letter to Pope Clement IV produced the Gregorian calendar reform.[159] If we abstract from the more precise results obtained by means of better graduated instruments, Bacon's method of computing time remains in use till the present day.

To indicate his regard for geometry we need only note the evident satisfaction with which he announced that Oxford university alone in all Christendom taught this branch of mathematics.[160] Here also Roger carefully prepared himself by intensive study. His own personal curiosity satisfied, he rejected the useless ramifications and wearisome repetitions of Euclid, Ptolemy, Alhazen, and others, declaring them to be prolix beyond all measure.[161] Then aiming as usual at practical utility[162] he selected just those theorems and propositions which interpreted nature and adapted luminous radiation for scientific purposes. But it was not from his African and Arabian preceptors that Friar Roger learned of the magnifying power in convex lenses, their combination to produce a telescope, and the concentration of parallel rays from reflecting surfaces formed by the revolutions of a conic section.[163]

Geometry

Not only in optics but in all other subjects whenever it was useful he explained, described, and expanded his theories and experiments by appropriate geometrical designs and diagrams.[164] Those who belittle Roger's talent would do well

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[158]D. E. Smith, "The Place of Roger Bacon in the History of Mathematics," *Roger Bacon Essays*, p. 181.

[159]J. F. C. Hearnshaw, *Medieval Contribution to Modern Civilization* (New York: Henry Holt and Company, 1922), p. 142.

[160]J. M. Lenhart, O. M. Cap., *Science in the Franciscan Order*, p. 19.

[161]A. G. Little, *Opus Tertium*, p. 20.

[162]L. Thorndike, *A History of Magic and Experimental Science*, II, 648.

[163]J. H. Bridges, *Opus Majus*, I, xxxv.

[164]L. Thorndike, *op. cit.*, II, 648.

to read his *Perspectiva* and become acquainted with his geometrical ingenuity.[165] This versatile cleverness—to catalogue a few items—the *Doctor Mathematicus* displayed in architecture, civil and military engineering, the building trades and mechanical arts, and in the construction of much improved astronomical, musical, optical, barological, physical, surgical, and chemical instruments.[166] How splendid must have been the practical mathematical mind that devised all this!

Geography

The First Geographer of the Middle Ages might our Friar fittingly be called on the basis of his systematic description of Europe, Asia, and a part of Africa.[167] For those who would question this title, one need but refer to the scientific spirit and painstaking inquiry which distinguished and contrasted Roger's work from the mere copying of former incorrect charts by practically all contemporary map publishers.[168] While it is true that he reproduced the principal doctrines of the Arabs, Friar Roger, too advanced to be deceived by their errors, recognized the false symmetry and the compromise between the real and the traditional in Saracen geography. He added, moreover, theoretical variations of his own, especially his conjecture of a second world summit, which Columbus thought might be a continent in the western hemisphere.[169]

In this subject again Roger's excellence rested upon his objectivity and mathematical genius. The former he manifested by the use of exceptional first hand information obtained from the heroic Franciscan missionaries, John of Plano Carpini and William Rubruck. During the years 1245-1247 and 1253-1255 the latter had traveled across Asia as far as Karakorum in central Mongolia, the capital of Jenghiz Khan's successors. In

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[165]J. H. Bridges, *Bacon's Life and Work*, p. 51.

[166]H. Felder, O. M. Cap., *Studien im Franziskanerorden*, p. 424.

[167]F. J. C. Hearnshaw, *Medieval Contribution to Modern Civilization*, p. 143.

[168]C. R. Beazley, *Dawn of Modern Geography* (London: John Murray, 1901), II, 466.

[169]C. R. Beazley, *Dawn of Modern Geography* (London: John Murray, 1897), pp. 404, 405.

at least six geographic books Roger organized and reproduced the information supplied by these predecessors of Marco Polo.[170]

The truly Baconian results in this science, however, were due to his mathematical knowledge. Thus, starting from his exact measuring of time Roger seems to have been the first to understand the need of an accurate, astronomical survey for the determination of East and West.[171] He also first described the climatic effects produced by the sun's passage upon the ecliptic.[172] This intelligence enabled him to construct before all others a comprehensive map of the world on which he attempted to determine mathematically the longitude and the latitude of the principal cities.[173] One authority has enthusiastically hailed this work as the greatest achievement of the scholastics, because it was issued independently of and before the rediscovery of Ptolemy's *Geography*.[174] Overgenerous though this encomium may be Bacon's masterpiece became the model for all future geographers until after the finding of the New World. Surprisingly near the exact figure of today was Roger's computation of 20,400 miles as the equatorial circumference of our globe.[175]

World Survey

As indicated before, the cry of "Land! Land!" from Columbus's lookout off San Salvador can be traced ultimately to Bacon; for the great discoverer wrote in a letter to Ferdinand and Isabella of Spain that he was influenced in making

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[170]G. Golubovich, O. F. M., *Biblioteca Bio-Bibliografica Della Terra Santa* (Quaracchi: Tipografia del Collegio di S. Bonaventura), I (1906), 266-269, and II (1913), 404-411. The journals of Plano Carpini and Rubruk are contained in A. Van den Wyngaert, O. F. M., ed., *Sinica Franciscana* (Quaracchi, 1929), I, 27-130, and 164-332. Cf. also M. A. Habig, O. F. M., "Marco Polo's Predecessors," *The Catholic World*, August, 1934.

[171]J. H. Bridges, *Bacon's Life and Work*, p. 155.

[172]S. M. Brown, *Medieval Europe* (New York: Harcourt, Brace and Co., 1932), p. 326.

[173]A. G. Little, "Roger Bacon," *Proceedings of the British Academy*, (London, 1928), p. 279.

[174]J. M. Lenhart, O. M. Cap., *Science in the Franciscan Order*, p. 23.

[175]D E. Smith, "The Place of Roger Bacon in the History of Mathematics," *Roger Bacon Essays*, p. 180.

FRIAR ROGER BACON CONSULTS FRIAR WILLIAM RUBRUK
FOR HIS WORLD MAP

his daring venture by a statement in Pierre d'Ailly's *Imago Mundi*, declaring that fabled India could be reached by sailing westward. That statement Pierre d'Ailly had incorporated almost word for word from Friar Roger's *Opus Majus*, though for reasons of his own, he had declined properly to acknowledge it.[176]

Music

Quite naturally Roger's musical bent was fostered and in fact dominated by what we might call his mathematical subconsciousness, underlying each subject and continually forcing itself into view. Still, music to Roger meant more than sound. It included also gesture and this again comprised every form and art of elocution. Proceeding yet deeper he desired that the phenomena and effects of rhythmical cadence on the health and temper of man and beast should not only be observed but even scientifically studied.[177] Hardly had anyone thought of this before.

Realizing as he did the moral and theological importance of this art, Roger made his best contribution in this matter to Church music.[178] For the most part he aimed at the restoration of Gregorian chant, as we call it today.[179] Hence, he inveighed with all the fiery oratory at his command against those who neglected its simple beauty to introduce sentimental melodies or barbarous clangor into the House of God. In place of such abuses Roger earnestly advocated a moderate volume of dignified music to enhance the liturgy, since he well understood the power of harmony to elevate the mind of man to the supernatural.[180]

Especially with the clergy did Roger plead that they and all aspirants to their sacred state be suitably instructed and proficient in the liturgical singing of the Church. Yet not clerics alone, but all men in his estimation should possess some

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[176]A. G. Little, "Bacon's Life and Work," *Roger Bacon Essays*, p. 30.
[177]J. H. Bridges, *Opus Majus*, I, lviii.
[178]R. B. Burke, *The Opus Majus of Roger Bacon*, I, 256-260, and II, 786.
[179]H. Felder, O. M. Cap., *Studien im Franziskanerorden*, p. 435.
[180]H. Felder, O. M. Cap., *op. cit.*, pp. 443-446.

theoretical and practical knowledge of vocal and instrumental music for the sake of culture, if for no other reason.[181] Thus, in his own Order and in as much of Christendom as he could influence Friar Roger gave a strong impetus to the study and advance of music.

General Estimate

For a general estimate of Roger's place in the mathematical Hall of Fame we may adduce the evaluation of his achievements by an eminent and conservative critic. In his own time Friar Roger had no superior, and there have existed few in any later period, who have shown such a love for this study, such familiarity with its standard authors, such clear ideas of possible use in practical life, and such a conviction of its utility in a general education. Where others surpass him in detail, Friar Roger rises much higher in total worth.[182]

To indicate our Friar's preternatural reputation among men the following anecdote is typical. The chronicler of an Old English monastery, while noting the fact that Friar Bungay was exceedingly learned in mathematics, added that he must have been taught either by Satan or by Roger Bacon. Not enviable company we admit, but the statement nevertheless paid a high compliment to Bacon's ability.[183]

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[181]H. Felder, O. M. Cap., *op. cit.*, p. 425.

[182]D. E. Smith, "The Place of Roger Bacon in the History of Mathematics," *Roger Bacon Essays*, p. 183.

[183]C. R. Gibson, *Heroes of Science* (London: Sealey, Service & Co., Limited, 1913), p. 45.

CHAPTER VII

NATURAL SCIENCES

Saint Francis of Assisi had lived and died as God's joyful Troubadour of Nature; and Francis' ardent love for every created thing his spiritual son, Friar Roger, imbibed, changed, developed into purposive, scientific observation[184] to help his fellowmen and to place the infant sciences upon a secure, independent footing. Compared to the old, dry, speculative way, Roger's improved method of studying nature appeared as refreshing as the exchange of a stuffy classroom for the great outdoors, as the temporary shelving of the wearisome textbook to take up the mineral, the plant, the animate creature of mountain, stream, and meadow.

Love for Nature

How did Roger seek to attain his twofold aim of philanthropy and educational development? By investigation. Ceaseless scrutiny, not haphazard, but personal, intelligent, exact examination constituted the foundation of his work in experimental science. By eliminating haphazard investigation he made his chief contribution to scientific observation, because with aimless contact excluded the other three qualities followed logically. He demanded that experimentation be personal, not too reliant upon the statement of another, for anyone might err. Intelligent, wide awake testing meant the studied placing of causes and conditions to produce a desired reaction at first dimly understood and only partly expected, nevertheless bound to be effected with greater ease and more definitely controlled as acquaintance ripened. Thus, in regard to the phenomenon of the rainbow, Roger mentions eighteen methods in his *Opus Majus* by which this effect could be oth-

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[184]A. Gemelli, O. F. M., *The Franciscan Message to the World*, translated by H. L. Hughes (London: Burns, Oates & Washbourne, Ltd., 1934), p. 64.

[185]J. H. Robinson, *History of Western Europe*, p. 273.

erwise observed in nature or artificially reproduced and considered.[186]

Thirdly, observation of natural phenomena required exact computation, as perfect as mathematics could provide, for the purpose of checking experiments and venturing into new fields of inquiry.[187]

In this way our Friar demanded a definite, improvable technique, which, although it contained much of the trial and error method, approached as near to a satisfactory procedure as man had developed until modern times; and if one takes into account the means at his disposal, it compares favorably with the practice of even the present day. To criticise him severely because his work does not come up to twentieth century standards seems as ridiculous as it is unfair.

A Technique

In the favorable environment created by his method and necessary instruments—personally made by him at times[188]—Friar Roger confidently expected nature to unburden its secrets for the enlargement of knowledge and the unmasking of frauds perpetrated by magicians and charlatans.[189] Like a medieval Houdini he occupied a unique position in pointing out that the effects produced by the antics of such sleight of hand artists and imposters did not necessarily emanate from the evil spirits, but for the most part were merely applications of natural powers hidden as yet from most men. Accordingly he urged upon his patron, Clement IV, that the black arts should be diligently studied and unmercifully exposed by competent investigators licensed through papal authority.[190] A prudent caution this, as history has shown.

That Roger felt himself qualified to institute such investigation we know from the quaint, old chronicle, *Liber Exem-*

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[186]R. B. Burke, *The Opus Majus of Roger Bacon*, II, 588, 589.
[187]J. E. Sandys, "Roger Bacon," *Proceedings of the British Academy 1913-1914* (London, 1914), p. 387.
[188]W. R. Newbold, *Cipher of Roger Bacon*, p. 18.
[189]R. B. Burke, *op. cit.*, II, 587.
[190]A. G. Little, *Opus Tertium*, p. 17.

plorum, written by an unknown English Franciscan. For at least five nights the writer and Friar Roger attended the seances of a Spanish magician to note down carefully whatever occurred during the incantations, in the course of which even an evil spirit seemed to speak for their benefit under the medium's questionings.[191]

Not morbid curiosity but utility moved Roger to these examinations, for his *Quintessence* (as he styled it) investigates all magic arts, as the logician examines a sophistry to expose its fallacy.[192]

Medicine

Medicine proved to be the first profession to which Friar Roger applied his new scientific method, "since it is more necessary to man than many other sciences."[193] To regard it in this way was only consistent with his program, whereby all natural sciences secondarily aimed at the comfort and better care of the human body and the prolongation of life. Thus we find that thirty-four pages of the fourth part of Roger's *Cipher* treat exclusively of the pharmaceutical powers inherent in flowers, fruits, leaves, and roots together with the special apparatus needed to prepare them as drugs.[194]

These latter, Roger declared, doctors must understand as thoroughly as possible. The means to make their acquaintance consisted in painstaking experimentation in chemistry and botany, or, as he styled it, "scientific agriculture." Only his reverence for the human body restrained him from experimenting with drugs upon it also. He succumbed, however, to the temptation of finding out personally just how a certain purgative called *Benedicta* would react. So painful did the experience prove that Roger later stated the medicine should rather have been named *Maledicta*.[195]

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[191]A. G. Little, *Liber Exemplorum (Aberdoniae: Typis Academicis*, 1908), p. 22.
[192]A. G. Little, *Opus Tertium*, p. 47.
[193]R. B. Burke, *op. cit.*, I, 56.
[194]W. R. Newbold, *op. cit.*, p. 46 *et seq.*
[195]A. G. Little, *Studies in English Franciscan History*, p. 202.

Roger's favorite cure-all proved to be not our potent vegetable, spinach, but rhubarb. From the enthusiastic description of its beneficial effects upon himself it seems that rhubarb must have been perfectly suited to his system both as a cathartic and a tonic. "All other medicines weaken more or less; this alone strengthens."[196]

Thermometer

In his medical work, *De graduatione medicinarum,* Friar Roger, either from his knowledge of Hippocratus or as a result of his own researches pointed to the invention of the modern thermometer in combating disease by declaring that the patient's degree of temperature and an exact uniform scale for measuring temperature are necessary for judging the condition of the sick.[197]

Safeguarding good health constituted the prime consideration of medicine according to Roger's mind and his counsels and cautions toward this end are surprisingly modern and efficient. Preventive medicine became the strongest point in his treatises,[198] since he well knew from months of sickness how difficult the repairing of the delicate human organism could be.

To maintain bodily vigor Roger merely urged simple health rules. In taking this stand, however, he opposed the professional practice of the time, since on his own testimony "scarcely one physician in a thousand will give this matter even slight attention."[199]

Health Rules

Get your fresh air; secure sufficient sleep; take your daily dozen; relax your nerves; never permit your system to become clogged with waste matter; be mentally and morally clean—and vigorous, glorious health results.[200] This is the prescription of Friar Roger Bacon, as efficacious in 1936 as in 1266. Like-

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[196]A. G. Little, *op. cit.,* p. 203.

[197]A. G. Little, *De Retardatione Accidentium Senectutis* (Oxford: E Typographeo Clarendoniano, 1928), p. xliii.

[198]R. B. Burke, *The Opus Majus of Roger Bacon,* II, 618.

[199]R. B. Burke, *op. cit.,* II, 617.

[200]A. G. Little, *op. cit.,* pp. 78 & xliii.

wise did Roger understand the modern practice of dieting; for, by carefully regulating the quality and quantity of his own food he restored his own shattered health.[201]

Certainly noteworthy appears his contention that the average span of life can be appreciably lengthened by the good physical condition of the parents, the continual observance of the laws imposed by hygiene and morality, plus the use of some invigorating elixir, which Roger hoped to develop by his chemical researches.[202] The increased longevity of our own day is in no small measure the result of the observance of rules such as were advocated by the Oxford Friar. Again, his persistent search and precious confidence in the efficacy of artificial compounds gave the initial impetus to chemistry's magnificent share in medicine's development.[203]

It has also been said that his discourses on inherited diseases, on the sympathetic effects of malevolent and benevolent personalities toward their victims or beneficiaries, on the psycho-therapeutic power of charms and auto-suggestion would be to the credit of a modern writer and investigator.[204] Take, for example, his advice on the perennial quest of youth. "Listen to beautiful music, look at beautiful things, hold stimulating conversations with sympathetic friends, wear your best clothes, and talk to pretty girls."[205] Has human nature changed? To indicate Roger's surgical knowledge we cite one example taken from his so-called *Paris Medical Text.*

Surgery

Pope Clement IV had been suffering from a stone in the bladder. Hoping to rid himself of this painful malady or at least mitigate its sharpness he sought medical advice from Friar Roger, who promptly furnished it in an expert, almost professional manner. He believed an operation necessary and

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[201]J. N. Leonard, *Crusaders of Chemistry* (Garden City, New York: Doubleday, Doran & Company, 1930), p. 37.
[202]R. B. Burke, *op. cit.*, II, 617, 618.
[203]H. Felder, O. M. Cap., *Studien im Franziskanerorden*, p. 470.
[204]T. L. Davis, *Roger Bacon's Letter*, p. 2.
[205]A. G. Little, *Studies in English Franciscan History*, p. 202.

minutely described—to mention a few details—the hygiene, the exact kind of incision required, the careful check-up requisite during convalescence, the antiseptic and pain-deadening properties in tincture of creosote for the treatment of the wound. However, the Holy Father drew the line at Roger's "newfangled" medical and surgical directions and died apparently of uremic poisoning four months later in November 1268.[206] This case alone ably demonstrated that the Oxford Friar possessed a wealth of medical knowledge and a surprising surgical technique for the middle of the thirteenth century.

If one were to single out Friar Roger's outstanding characteristic in the last two subjects mentioned, very likely it would be his boundless trust in the useful potentialities of natural things for medicine and surgery that thinking man can discover by methodic and ceaseless investigation.[207] This hope shines forth all the more brilliantly because of the crude state of the natural sciences in his time. His expectations have been remarkably fulfilled by the well nigh uncanny progress already made and the further progress yet to come.

While not professedly a medical student Friar Roger's contribution to medicine bespoke such high caliber that Arnold of Brescia, the greatest physician of his age, less than twenty years after the former's death copied his words, line for line with few alterations, and brazenly presented the whole as his own original production to King Robert of Naples and Jerusalem thinking, perhaps, that no one would ever again hear of Friar Roger Bacon of England.[208] Such plagiarism by an otherwise eminent authority and its dedication to a royal patron of art and science speaks more eloquently than any formal commendation could do of the exceptional quality of Roger's medical ability.

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[206]W. R. Newbold, *Cipher of Roger Bacon*, pp. 176-178.
[207]A. G. Little, *De Retardatione Accidentium Senectutis*, p. xxxii.
[208]A. G. Little, *op. cit.*, pp. xlii, xliii.

Alchemy for Bacon formed merely the stepping stone to the higher science of chemistry, and so he correctly evaluated the former's worth. Hence, his comprehensive mind having grasped all the rudiments of the subject, Roger drafted principles of action whereby he employed the knowledge of those before him in his own inimitable way to arrive at many new discoveries.[209] "For the secrets of alchemy can procure an abundance of material goods, enough to satisfy a world."[210]

Alchemy

In common with the alchemists Friar Roger recognized the need of a practical acquaintance with the methods of distilling, calcining, and separating the various substances of their quest together with the freedom of reasoning upon, pooling, and generalizing their experience.

Unlike them however, Roger completely rejected the central hypothesis, that all objects originate from a common undefined something. In its stead he postulated the existence of distinct, material substances, each characterized and distinguished from all others by its own peculiar properties. "I have proceeded to the production of things from the elements, and I have treated the entire subject up to the special composition of animals and plants."[211] To passages like this it seems we must look for the beginnings of modern chemistry.

Elements

Besides the ordinary metals known to the ancients Friar Roger appears to have isolated quite a few of the rarer elements; for in his writings have been found the formulae for extracting phosphorus, manganese, bismuth, and others from their compounds.[212] Solar furnaces whereby he melted and calcined rocks helped Roger much towards these discoveries.[213]

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[209]M. M. Pattison Muir, "Roger Bacon: His Relations to Alchemy and Chemistry," *Roger Bacon Essays*, pp. 318-320.

[210]A. G. Little, *Opus Tertium*, p. 80.

[211]A. G. Little, *op. cit.*, pp. 77, 78.

[212]A. D. White, *History of the Warfare of Science and Religion* (New York: Appleton and Company, 1928), p. 387.

[213]A. G. Little, *op. cit.*, p. 52.

Possibly of interest might be our Friar's evaluation of the medieval bibliography for alchemy, already "more than a wagon could carry," replete with endless obscurity and reducible to a few words.[214]

More fully than others Roger learned from his alchemical experiments that effort, activity, and change constitute the marks of physical substances and by this realization he anticipated the modern theory of energy.[215]

Chemistry

With advanced ideas such as these Roger diverted alchemy from the vain search after the method of converting baser metals into gold and silver and became the first chemist in the strict sense of the term.[216] Undoubtedly he deserves this title by reason of his demarcation of the field and mission of inorganic and organic chemistry. His words read:

> This science comprises the combination of the elements and all living things; namely primary substances, simple and complex liquids, ordinary minerals, precious stones, marble, gold and the other metals, the sulphurs, salts, and pigments, azure, minium, and all the dyes, the oils, resins, and numberless other substances not treated in the books of Aristotle, untouched by present-day dabblers in natural lore, unknown to the entire multitude of the Latins.[217]

Quite an extension beyond the metal-bound interest of the alchemists! And in this way Roger hit upon the very foundation of bio-chemistry.

> And because students do not understand this science, neither do they grasp that which immediately follows and must be clear to them; namely, the constitution of animate creation, of plants, animals, and men. For the composition of the human, brute, and

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[214]A. G. Little, *Opus Tertium*, p. 80.

[215]M. M. Pattison Muir, "Roger Bacon: His Relations to Alchemy and Chemistry," *Roger Bacon Essays*, pp. 318-320.

[216]M. M. Pattison Muir, *loc. cit.*, pp. 318-320.

[217]H. Felder, O. M. Cap., *Studien in Franziskanerorden*, pp. 399, 400.

vegetable organism is derived from the mixture of elements and fluids and governed by the same laws by which inanimate creation is ruled.[218]

Applications

Thus, Friar Roger monopolized chemistry till the seventeenth century and inaugurated its glorious career of service toward physiology, medicine, agriculture, industry, transportation, and all manner of invention for human comfort and physical well being.[219] Eighteen treatises on chemistry and its applications which emanated from his fertile brain have so far been discovered.[220]

A special delight did Friar Roger derive from the submission of counterfeit products to his chemical laboratory tests in order to analyse them and confound their falsifiers, as he wrote in his *Opus Tertium*.[221] In this way he contributed the first instance of a scientific chemical detection of fraud and crime.

To show that chemical science is still rediscovering some of Roger's chemical reactions, we will cite one example from the deciphered portion of his *Paris Medical Text*. This contained a minutely described formula for obtaining metalic copper by an entirely unknown process. Urged on by the novelty of the experiment a professor at the University of Pennsylvania tried the method and obtained the metal just as Roger had directed.[222]

As a chemical hobby Roger investigated explosive combinations and tested their ability to promote locomotion for land and water craft. Hence the utilization of gasoline and crude oil for travel may be looked upon as the development of Roger's idea.[223]

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[218]*Ibid.*, p. 400.
[219]W. R. Newbold, *Cipher of Roger Bacon*, p. 3.
[220]J. J. Walsh, *Catholic Churchmen in Science* (Philadelphia: Dolphin Press, 1910), p. 53.
[221]A. G. Little, *Opus Tertium*, p. 88.
[222]W. R. Newbold, *op. cit.*, pp. 181-184.
[223]J. J. Walsh, *op. cit.*, p. 54.

In this connection a few words about the invention of gunpowder seem to be in place. If nothing else, Friar Roger was the first European to make mention of gunpowder.[224] Since its Chinese and Arabian origin has been disproved, we may add that good arguments exist for its actual invention or chance discovery by Bacon during his long life of research. He wrote about gunpowder's main characteristics before anyone else had even mentioned the substance. He possessed its exact chemical formula and hid it within a subtle cipher.[225] How explain the prior description and the precaution used, if Roger were not the finder? Not only its incendiary property but also its explosive power were known by him; for he declared a number of times that by its use an army could be destroyed.[226] Perhaps even gunpowder's projectile force had begun to dawn upon his inquiring mind; in his *Opus Tertium* he remarked: "If an instrument of solid material be used [to enclose the powder], then by far greater would be its power;" and "it might be used at any distance we wished and those who thus employed it would not be harmed."[227]

Inventor of Gunpowder

What leads Friar Roger may have furnished for his fellow Franciscan Berthold Schwarz of Freiburg or vice versa cannot at present be determined, because the latter's life span in history has not been definitely fixed as yet. If they were contemporaries, then a mutual exchange of ideas would have been most natural because of their common alchemical propensities and religious profession.

Therefore, despite contrary opinions,[228] until better arguments are adduced to reveal a different inventor of gunpowder

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[224]W. W. R. Ball, *History of Mathematics* (London: Macmillan & Company, Limited, 1919), p. 174.

[225]W. R. Newbold, *op. cit.*, pp. 141-143; and H. W. L. Hime, "Gunpowder," *Encyclopedia Britannica* (1929), II, 890.

[226]H. W. L. Hime, "Roger Bacon and Gunpowder," *Roger Bacon Essays*, pp. 321-335.

[227]A. G. Little, *Opus Tertium*, p. 51.

[228]L. Thorndike, *History of Magic and Experimental Science*, II, 688.

and discoverer of its projectile power, Friar Roger Bacon seems to hold the field.

Geology and Botany

Friar Roger's patient investigations into the nature of various rocks and ores to ascertain their contents and properties in behalf of medicine, alchemy, and chemistry necessarily gave him an excellent start in mineralogy.[229] Later on this close scrutiny of all manner of stones enabled him to form the first deductions which constitute geology's inception as a science.[230]

Life not only in its higher orders but also in its lower forms fascinated the nature lover of Oxford. Hence Friar Roger devoted much time and writing to the plant world.[231] In his *De Vegetalibus* many interesting facts concerning the structure and life processes of plants have been revealed.[232] Knowing these data one need not be surprised that Roger could even specify just what type of soil each required.[233] Furthermore his experiments saved him from many mistakes common to his contemporaries and enabled him to state that the botanical works of Aristotle then in use were unreliable and that the subject demanded an entirely different treatment.[234] Perhaps the answer in part to this criticism may have been the one hundred and twenty-five pages in his Cipher manuscript[235] covered with botanical drawings and explanations and followed by five full pages of text all as yet undeciphered, but indicating by their very make-up a noteworthy advance in this science of the earth's flora.

Mounting higher in creation's kingdoms Roger's tireless pen furnished a detailed classification of the domestic and

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[229]H. Felder, O. M. Cap., *Studien in Franziskanerorden*, p. 397.
[230]A. Geikie, *The Founders of Geology* (London: Macmillan & Company, Limited, 1897), p. 5.
[231]H. Felder, O. M. Cap., *op. cit.*, p. 398.
[232]*Ibid.*, p. 398.
[233]J. H. Bridges, *Opus Majus of Roger Bacon*, I, xlvi.
[234]H. Felder, O. M. Cap., *op. cit.*, p. 399.
[235]W. R. Newbold, *Cipher of Roger Bacon*, pp. 44, 45.

Zoology and Physiology

wild animals of pasture, forest, and desert[236] together with painstaking studies concerning their anatomy and physiology.[237] We heartily regret in this and other instances that the inaccessibility of primary sources hindered the citation of concrete examples to clarify statements which on their face value might appear exaggerated.

Most intensely of all Roger investigated the body of man, not only the conditions conducive to perfect health, but likewise the body's development and structure.[238] Indicative of this investigation is the third section[239] of his Cipher—*the Voynich Manuscript*—containing four solid pages of text and twenty-eight folia of drawings intertwined and margined with explanations of human embryology. While this chapter remains as yet only partly solved, the general meaning of the scores of figures cannot be mistaken. It is to be hoped that the work's cleverness and originality will not forever defy the efforts of experts to translate completely its pages into modern diction.

Plate VIII[240] depicting the development of the ovum merits special attention, because the person who drew it possessed a very simple or more probably a compound microscope. If this were not the case, we simply leave to the reader the explanation, how the single, orderly, differentiated rows of cells, even topped by curved cilia, could have been sufficiently distinguished by any other means. Truly, this drawing would be a credit to a present day student. Should Roger have been its author and creator, as abundant evidence proclaims, then to him also must the first microscope be ascribed. With it his eyes must have viewed in scientific

Embryology and Histology

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[236]J. H. Bridges, *op. cit.*, I, p. xlvi.
[237]H. Felder, O. M. Cap., *op. cit.*, p. 397.
[238]J. H. Bridges, *op. cit.*, I, p. xlvi, xlvii.
[239]W. R. Newbold, *op. cit.*, pp. 44, 45.
[240]W. R. Newbold, *op. cit.*, p. 51.

ecstacy histological sights and wonders never before beheld by human gaze.

Roger's sketches seem to postulate that, thanks to such an instrument, he observed phenomena unknown after him for more than four hundred years until 1677, when Leeuwenhoek and Hamm re-discovered the seminiferous tubes, microscopic cells with nuclei, possibly also spermatizoa, and the early stages of the embryo's development.[241]

In the light of these data reports of Roger's progress in human anatomical and physiological knowledge[242] become much more plausible. Likewise his deviations from much of preceding and contemporary thought, for example, his theory that the brain is the center of the entire nervous system,[243] now have a readier explanation.

One need not be overly surprised to find Roger the inventor of such an epoch-marking mechanism as the microscope. In fact quite a number of arguments point to this very conclusion. Even his most adverse critics admit that he was well versed in the workings of lenses. He had thoroughly assimilated the optical contributions of Euclid, Ptolemy, Alhazen, and others; he possessed the advanced ideas of Grosseteste, himself but a few steps removed from this discovery.

Optics

Thus wrote the latter in his *de Iride:* "This part of Perspective will make very distant things seem very near. . . . so that it may be possible for us to read the tiniest letters at an incredible distance or count grain or sand or grass or any tiny object."[244] Here Friar Roger found the theory. On him now devolved the task of applying it to practice, of personally constructing suitable lenses, as he narrated in his *Opus Majus*

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[241]J. M. Manly, "The most mysterious Manuscript in the world; did Roger Bacon write it and has the key been found," *Harper's Magazine,* CXLIII (1921), 193.

[242]H. Felder, O. M. Cap., *Studien im Franziskanerorden,* p. 397.

[243]H. Felder, O. M. Cap., *op. cit.,* p. 399; and R. B. Burke, *op. cit.,* II, 428.

[244]J. E. Sandys, "Roger Bacon," *Proceedings of the British Academy, 1913-1914,* p. 385.

and *Opus Tertium*,[245] since European craftsmen did not as yet possess the requisite skill.[246] His use of mathematics as the foundation[247] and criterion of experimentation supplied much more reason and hope for progress and ultimate success. From all geometry he had selected just those theorems that could be utilized for life's enrichment.[248] Finally in almost every subject he demonstrated the knack of habitually improving and in his own ingenious way applying to various unknown uses what others had bequeathed.[249] Considering all these actual advantages we might say Friar Roger would almost have been deserving of censure, if he had not produced the world's first crude microscope! At any rate until we obtain greater historical surety, one can at least affirm that, if Roger did not, he could have constructed this delicate instrument, because he had the required knowledge of the nature and effects caused by light rays passing through convex and concave lenses.[250]

Microscope

This same acquaintance led him to speak casually in his *Opus Majus* about eyeglasses as "useful to old persons and those who have weak eyes, because no matter how small, the letters can be enlarged for them to a sufficient size."[251] Thus Roger regarded them as an ordinary aid to better vision forty-five years before their invention is historically credited to anyone else.[252] Was he the first also to design and manufacture them?

With the following words Friar Roger at least forecasted our modern telescope:

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[245]W. R. Newbold, *op. cit.*, p. 16.
[246]W. R. Newbold, *Cipher of Roger Bacon*, p. 18.
[247]W. W. R. Ball, *Short History of Mathematics*, p. 176.
[248]L. Thorndike, *A History of Magic and Experimental Science*, II, 648.
[249]J. H. Bridges, *Bacon's Life and Work*, p. 106.
[250]"Roger Bacon," *Encyclopedia Americana* (Chicago: Americana Corporation, 1932), III, 25.
[251]*Ibid.*

FRIAR ROGER BACON'S MICROSCOPE

"We might count dust or sand by reason of the magnitude of the visual angle" (J. H. Bridges, *Opus Majus*, II, 165).

> Similarly mirrors might be erected on an elevation opposite hostile cities and armies, so that all that was being done by the enemy might be visible. This can be done at any distance we desire if they are placed in the manner required. Therefore they can be placed more closely and more remotely, so that we might see an object as far off as we pleased.[253]

Possibly this may be mere theory, but it appears rather to be the directions of a man who has experimented with actual instruments and now suggests a practical use for them.

Even a periscope may have been outlined by the words that follow:

> Mirrors, moreover, can be so arranged that as many objects as we desire may be visible and all that is in the house or in the street; and anyone looking at these objects will see them as they really are, and when he hastens to the places, where they appear, he will find nothing. For the mirrors will be concealed in such a manner with respect to the objects that the positions of the images are in view, and the images appear in the air at the intersection of the visual rays with the catheti, etc.[254]

Of course Roger did not enclose this arrangement in the compact periscope tube of today. That step awaited later development.

To answer the need for greater exactness in viewing objects at longer distances Friar Roger put the reflecting telescope on paper at least, if not in actual glass and metal. The proof for this assertion is the positive, direct, and thus far uncontradicted evidence that our Oxford optician left in writing minute instructions for the construction of such a telescope and according to these detailed mathematical specifications a successful one was made before the year 1571 by Leonard Digges.[255]

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[253]R. B. Burke, *Opus Majus of Roger Bacon*, II, 518, & II, 511.
[254]R. B. Burke, *op. cit.*, II, 581.
[255]W. R. Newbold, *Cipher of Roger Bacon*, pp. 19, 20.

Not satisfied with merely improving vision by mechanical means Roger through careful experimentation and clear reasoning discovered and demonstrated many new facts concerning its complex nature in the human eye as one hundred and sixty-four pages in his *Opus Majus* alone attest.[256] From these studies various later finds on the structure and operations of man's organ of sight spontaneously followed.[257]

Branching over to the medium of sight Roger devised light theories which are striking by reason of their modernity.

Theories of Light

Thus, in opposition to all earlier physicists our Friar propounded the theory that the passage of light is not instantaneous. Several centuries later the truth of this conclusion became established and universally recognized.[258] To our Oxford scientist belongs also the original and reasoned conclusion that illumination is not caused by an emanation but flows from a propagation of movement through successive parts of a medium.[259] To speak conservatively, this is an anticipation of, if it does not constitute, the undulatory theory of the present, and still a theory by the way.

So outstanding, clear, and advanced were Roger's grasp and exposition of mathematical optics that his work remained the fundamental text books in Europe for two hundred years after his time.[260]

While hardly a comparison exists between the giant, two hundred-inch eye for the immense reflecting telescope to be erected on Mount Palomar in California and the modest instrument specified by Friar Roger, his formed the beginning, the first successful product in that long line of optical engineering triumphs. In this light Roger's revolutionary con-

Astronomy

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[256]R. B. Burke, *op. cit.*, II, 419-583.

[257]R. B. Burke, *op. cit.*, II, 430 *et seq.*, II, 466 *et seq.*

[258]J. E. Sandys, "Roger Bacon," *Proceedings of the British Academy 1913-1914*, p. 380.

[259]J. E. Sandys, *loc. cit.*, p. 274; and R. B. Burke, *op. cit.*, II, 489-490.

[260]F. J. C. Hearnshaw, *Medieval Contribution to Modern Civilization*, p. 142.

tribution to astronomy becomes apparent. Without him the science for a much longer period would have been restricted to the comparatively feeble keenness of the human eye. With his product and its improvement the far reaches of the heavens will be enlarged for man's inquisitive gaze almost ten thousandfold.

The astronomical chapter of his *Cipher*[261] contains twenty-six pages of annotated drawings possessing such originality of treatment that hardly any production of the century bears any resemblance to them. We note only one, an excellent diagram the lines and deciphered legend of which informs us that the representation depicts the great Spiral Nebula of Andromeda with its component parts colored blue, yellow, and green.[262] Even at present this wondrous sight can be seen only through powerful telescopes. What other inference must be invariably drawn than that the astronomer who saw and drew this phenomenon must have been aided by some efficient, artificial means, because this star cluster simply lies beyond the limits of the naked eye. This highly privileged individual in all probability was the wizard of Oxford, Friar Roger Bacon.

Although apparently unaided by a telescope before 1277, Roger with the assimilated astronomical lore of those before him produced a lengthy treatise in his *Opus Tertium* concerning the movements of the celestial bodies.[263] Of special note in this connection are his criticism and detection of the flaws in the prevalent theories of his predecessors. Pertinent objections such as these may well have provoked the researches which set Copernicus on the right track.

Prior to Roger it appears that no one correctly attributed the ocean tides to the movement of the moon,[264] and hit upon

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[261]W. R. Newbold, *Cipher of Roger Bacon*, p. 44.
[262]*Ibid.*, p. 123.
[263]P. Duhem, *Opus Tertium* (Ad Claras Aquas: Ex Typographia Collegii S. Bonaventura, 1909), pp. 98-137.
[264]W. T. Sedgwick and H. W. Tyler, *A Short History of Science* (New York: Macmillan Company, 1917), p. 181.

the nature and composition of meteors as "fiery vapors,"[265] nor declared the stars to be numberless:

Tides & Meteors

"Then there are other stars in infinite number, the size of which cannot be ascertained by instruments, and yet they are known by sight and therefore have sensible size with respect to the heavens, like the part with respect to the whole."[266]

Using and improving upon the principles of Ptolemy and the Mohammedans, Roger measured the distance, altitude, and size of many heavenly bodies,[267] even the confines of the universe![268] Although much too cramped as were his limits of the sky, still he introduced into Europe those breath-taking figures we now take for granted in astronomy.

The comparative poverty of Roger's original contribution to astronomy before 1268, as manifested in his writings compared to what it could have been for one possessing a telescope leads me to think that the construction of this instrument must be assigned to the years between 1277 and 1290, when he could no longer freely make known his findings. Still, words such as the following in the *Opus Tertium* might well indicate that much progress had already been made: "So, from an incredible distance we might read minute letters and number the grains of sand and see the sun, moon, and stars bowed low [*inclinari*] above our heads."[269]

Just as significant as in any other science were Roger's achievements in speculative and applied physics. To him color, heat, sound, and odor are wave radiations through space. Since Roger's words can best express what Roger thought, we shall use a few extracts and abstracts from his writings to describe what he taught.

Physics

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[265]R. B. Burke, *Opus Majus of Roger Bacon*, II, 400.
[266]R. B. Burke, *op. cit.*, I, 258.
[267]E. Stateczny, O. F. M., *Compendium Historiae Philosophiae*, p. 398.
[268]R. B. Burke, *op. cit.*, I, 249.
[269]A. G. Little, *Opus Tertium*, p. 41.

Color depends upon light and can be perceived by the sense of sight only under the eight conditions our Friar enumerated.[270] A thorough knowledge of these enabled him to explain natural phenomena such as the following.

> And according to this I demonstrate the cause of the sheen on the neck of the dove and the tail of the peacock according to the variance with which light falls upon them at different angles, so that a first person beholds one color, a second another, while looking at them at one and the same time.[271]

Heat is generated by motion and becomes greater where there is at the same time a strain or friction.[272] In this connection might also be mentioned what may be Roger's prophecy of the incandescent lamp: "But greater are the ever-burning lamps, which can be perpetuated through great cleverness by means of a small and invisible poultice, so that a candle appears as nothing in comparison."[273] Just what this chemical substance might have been and how it produced the desired effect we can only conjecture. Even bodies producing "cold light" were known and experimented with by Roger. "Something can be prepared which continually illuminates and burns without any combustion of the material."[274] Again one can only guess what this compound might have been, perhaps a phosphorous substance or carbonized wood.

Ever-Burning Lamps

> Sound consists of a series of tremors in the air produced in every direction to the ear, not by an accidental generation but by a principal one, which causes the air to vibrate to the ear and produces a real sound in it and in every direction.[275]

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[270] R. B. Burke, *Opus Majus of Roger Bacon*, II, 517.
[271] A. G. Little, *op. cit.*, p. 36.
[272] R. B. Burke, *op. cit.*, I, 189, 190.
[273] A. G. Little, *op. cit.*, p. 50.
[274] *Ibid.*
[275] R. B. Burke, *op. cit.*, II, 476.

This extract shows how correctly Roger understood the nature of sound. Not the general principle but only the details of our knowledge about sound has increased since his time.

> Odor not only produces a species but from the odorous body a vapor goes forth, which is a subtle body diffusing itself everywhere in the air, and when it comes opposite to the nostrils it multiplies its species to the organs of smell, and therefore, that vapor has real odor, just like the first odorous body.[276]

From these words likewise one may gauge the modernity and accuracy of Friar Roger's principles in physics.

Still more striking, however, appears his belief in rays that pass through the densest body, being, moreover entirely invisible to the naked eye.[277] Such a statement seems to indicate at least a faint knowledge on Roger's part of some kind of radio-activity or rays of low wave frequency. This appears so remarkable that in the absence of more certain proof and of the evidence of experiments we are inclined to doubt the actuality of such a conclusion.

Radio-Activity

On the contrary we possess certain knowledge that Roger advocated a central organization which was to unite in itself the duties of a weather bureau, seismic station, astronomical observatory, health department, and comparative historical society, to record "the extraordinary happenings in the world as floods, earthquakes, comets, and meteoric showers *(cetere impressiones ignite notabiles)*, winds, seasons, famines, pestilences, changes of customs, philosophies, and laws, of thrones and governments."[278] This committee would seek the causes for the aforementioned events and endeavor to generalize this mass of data into natural and moral laws. These in turn would be incorporated into serviceable tables for common

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[276]R. B. Burke, *op. cit.*, II, 476.

[277]E. J. Sandys, "Roger Bacon," *Proceedings of the British Academy 1913-1914*, p. 387.

[278]A. G. Little, *Opus Tertium*, p. 14.

usage,[279] so that men might beneficially forecast the future to a certain extent.

Especially interesting is Roger's *Scientia de Ponderibus* wherein he ably discoursed before any other scholar on the science of weight or gravity now known as barology.[280] So far had he advanced that he recognized the law of gravity as we understand it today; namely, the gravitational pull of the earth and the heavenly bodies.[281] This he demonstrated by his very detailed explanation concerning the movements of the scale.[282]

Law of Gravity

Friar Roger's explicable achievement in physics consisted in his application of its theoretical principles to practical inventions which appear to belong to a period long after his day. Yet he wrote concerning them in such a matter of fact way that for a number of them at least this unusual man possessed undeveloped and crude working models.

For transportation on land, air, sea, even below the waves Roger described the automobile, railway,[283] airplane, steamship, and submarine.[284] The propelling force for these mechanisms appears to be some power-driven engine, because he wrote of an instrument for flying and one for navigation, which transports at high speed a boatload of armed men with, however, only one man driving."[285]

Self-propelling Engines

To span the world's great rivers the engineer of Oxford proposed suspension bridges;[286] to ease the back of porters he

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[279]A. G. Little, *Opus Tertium*, p. 14.
[280]J. H. Bridges, *Opus Majus of Roger Bacon*, I, xlv.
[281]E. Stateczny, O. F. M., *Compendium Historiae Philosophiae*, p. 395.
[282]R. B. Burke, *op. cit.*, I, 190-194.
[283]J. H. Robinson, *Readings in European History* (Chicago: Ginn and Company, 1904), I, 461.
[284]J. M. Lenhart, O. M. Cap., *Science in the Franciscan Order*, pp. 15, 35.
[285]A. G. Little, *op. cit.*, p. 18.
[286]J. H. Robinson, *op. cit.*, I, 461.

would construct the elevator;[287] and to explore beneath the surface of ocean and stream, he suggested a diving bell.[288]

Defense of Christendom

One of the main anxieties of Friar Roger consisted in the protection of Christendom against the offense of the Saracen and Tartar hordes. Regarding this problem he began as usual with a sound fundamental principle that a nation is as strong as its scientific research department,[289] which should bend every effort toward new and more powerful weapons of defense. On his part he contributed high explosives and the mobile tanks, "as scythe studded chariots full of armed men which travel with wondrous velocity, even though not drawn by an animal, to crush and tear through all obstacles."[290]

Even the employment of harmful bacteria and poison gas appear to be intimated by these words:

> Moreover against the foes of the state they [the experimentalists] have discovered important arts, so that without a sword or any weapon requiring physical contact they could destroy all who offer resistance. There are many kinds of these inventions. Some of them are perceived by no one of the senses, or by the sense of smell alone, and of these inventions Aristotle's book explains that of altering the air, but not those of which I spoke above. These last are of a different character, since they act by means of an infection. There are others also that change some one of the senses, and they are diversified in accordance with all the senses.[291]

The more one ponders over sentences like these the greater does one wonder just how far the brilliant Roger traveled along the paths of discovery.

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[287]J. H. Robinson, *op. cit.*, I, 461.
[288]J. M. Lenhart, O. M. Cap., *op. cit.*, p. 34.
[289]A. G. Little, *op. cit.*, p. 18.
[290]A. G. Little, *Opus Tertium*, p. 18.
[291]R. B. Burke, *Opus Majus of Roger Bacon*, II, 629.

Perhaps the precursor of the long sought death ray of future wars was described when he wrote "of burning glasses which are able to burn at any distance we wish everything hostile to the state, whether a camp or army, whether a city or any object whatsoever."[292]

These more striking examples of Roger's advanced ideas chosen from his fragmentary works only partly manifest his genius, because he lacked an adequate vehicle of expression. Even if he had invented a terminology for himself, it would have been well nigh unintelligible to his readers. For this reason he complained: "And so for the other numberless [wonders,] some of which I have touched in other places, yet neither here nor in the earlier works have I been able to explain all."[293]

Terminology

To get to Roger's full knowledge or as much as he committed to writing, we must wait until more of his books are recovered from the dusty shelves of old libraries.

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[292]A. G. Little, *op. cit.*, p. 18.
[293]*Ibid.*

CHAPTER VIII

HIS INFLUENCE

The encyclopedic intellect and the strong character behind the successes, that have required so many pages for only a summary treatment, necessarily produced a profound impression on his contemporaries and upon posterity, notwithstanding his over-zealous criticisms and despite the fact that Roger's ideas were centuries ahead of his time, and, as it appears, hundreds of years in advance of his own ability to understand the tremendous possibilities to which they gave birth.

Contemporary Regard

In his native England and especially at Oxford, its intellectual capital, Roger even from his youth was a shining light shaping and guiding the activity of the university. John Picus Mirandulanus and John Pitseus testified that to his fellow men and close associates Friar Roger's brilliancy approached little short of the miraculous. He seemed hardly ever to have had an equal, and so did he excel in every science and every branch of science that in each doctrine he appeared the most learned of all.[294]

Quite naturally then, Roger made articulate at least, where he did not to a great extent shape, the aspirations of the Franciscan School. No doubt our Friar eagerly accepted ideas from its other foremost teachers and students, but it seems to have been a matter of giving and taking even on the part of the learned Robert Grosseteste himself.[295] Thus, towards the end of his life the Bishop of Lincoln incorporated theories into his works that were distinctly Baconian; for example, his astrological treatise on the influence of the planets

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[294]L. Wadding, O. F. M., *Annales Minorum* (Quarrachi: Ad Claras Aquas, 1931), IV, 296.

[295]A. G. Little, *Studies in English Franciscan History*, p. 197.

and the use of a date according to the Mohammedan calendar.[296]

Friar Roger's fame soon became international and spread to Paris; and Saint Louis IX is said to have procured the transfer of our scholar to that city for the sake of augmenting the glory of the Sorbonne.[297] About this time Cardinal Guy Fulcodi, the former Archbishop of Narbonne, became impressed by reports of Bacon's prowess in experimental and intellectual activities; and this regard for Bacon he retained when he was promoted to the papacy. The secret command he issued after he had become pope supplied the impetus for the completion of Bacon's three best works.[298]

To France

At Paris not only the prevalent over-indulgence in speculation, but also the torrent of vexations and calumnies springing from ignorance and envy[299] prevented Roger from exercising much influence in spite of his efforts to stem the attack. In Oxford, however, his authority and the impetus he had given to linguistic, mathematical, and scientific endeavors never died down completely, not even during the days of his enforced silence. In fact, before the end of the century serious attempts had been made to collect and circulate Roger's works. A few years later Pierre Dubois openly advocated the study and diffusion of our Friar's mathematical treatises.[300]

Exceptional men shortly after his time, as Blessed Raymond Lull, Arnold de Villeneuve, Walter Burley, Thomas Brawardine, Duns Scotus, to mention the most outstanding, became indebted to Roger, but in most cases his influence upon them has as yet not been definitely decided.[301] William de Mara, famous for his biblical correct-

Influence on Thinkers

[296] A. G. Little, *op. cit.*, p. 197.
[297] S. M. Brown, *Medieval Europe*, p. 239.
[298] W. R. Newbold, *Cipher of Roger Bacon*, pp. 7-13.
[299] L. Wadding, O. F. M., *Annales Minorum* (1931), IV, 296.
[300] A. G. Little, *op. cit.*, p. 220.
[301] A. G. Little, "Roger Bacon's Life and Work," *Roger Bacon Essays*, p. 29.

oria, and other Hebrew students of Friar Roger preserved and disseminated the appreciation for this study that they had imbibed from their enthusiastic master.[302]

Soon after his death fellow Franciscans and even the Dominicans opened colleges for the teaching of oriental languages.[303] In this way both orders showed that they admitted the truth of Roger's contentions, even though they had not relished his individual manner of making them. The papal recognition and partial solution of this problem was devised, as noted before, during the Council of Vienne, 1311.[304]

Perhaps even before his demise, about 1292, Friar Roger may have heard the heartening news that the General Chapter of his order had included in its Constitutions a recommendation for the study of the sciences.[305] By this enactment Roger's scientific program was encouraged and incorporated into the official curriculum of perhaps the most numerous and powerful religious organization in Christendom.

Influence in Italy

Let us now leave England and France of the early fourteenth century to inquire whether Roger was known on Italian soil. Such seems to have been the case. King Robert of Naples, who ruled between 1309 and 1343 and munificently encouraged learning, may have been the link between Friar Roger and the Italian Renaissance. Robert had spent his youth in Provence, where contact with England and Oxford would not have been unusual, traversed as the country happened to be by the trade routes between the East and the West. More important appears the fact that the king procured the Oxford Franciscan, William of Alnwick, as professor in the Royal University of Naples and his later elevation to the episcopal see of Giuvenazzo. This same William was followed at Oxford by an ardent student of Roger, William Herbert. Hence our Friar's authority among the English Franciscans had not notably declined. Even two

[302] A. G. Little, *op. cit.*, p. 29.
[303] *Ibid.*
[304] *Ibid.*, p. 26.
[305] J. M. Lenhart, O. M. Cap., *Science in the Franciscan Order*, p. 7.

treatises written by King Robert in his youth contained an Oxford flavor; while a number of transcribed scientific books and translations from the Greek, Arabic, and Hebrew seem to have been taken from the productions of England's master mind. Before more can be said concerning Roger's influence on this man the archives of medieval Naples must be examined and the catalogue of King Robert discovered.[306]

Copies of His Works

During the following centuries practical men consulted and borrowed unsparingly from Bacon's works, although they did not always acknowledge their indebtedness to him. Thus have been found from the thirteenth and seventeenth centuries at least twenty-seven copies[307] of Roger's *Perspectiva* which appear to have provided the beginning for the improved books of Francis Bacon and Descartes on optics.[308]

Repentant Oxford had once more received Friar Roger back into the family by the fifteenth century because from then on the undergraduates quoted its celebrated alumnus as an authority in their public debates.[309]

In Pierre d'Ailley's geography, known to Columbus, it was none other than Friar Roger's finger that pointed westward.[310] Fifty per cent of Paul of Middelburg's calendar reform has been traced to Roger. From this and other Baconian studies and reflections in astronomy Copernicus was moved to construct more and more exact tables dealing with the movements of the stellar and planetary bodies until finally he hit upon his heliocentric theory.[311] And our Friar's introduction and improvement of Arabic learning made Galileo possible.[312]

Not only in Italy but later also in Germany, France, and England Roger's grammatical works promoted the rebirth of

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[306]A. G. Little, *Studies in English Franciscan History*, pp. 218, 219.
[307]A. G. Little, "Roger Bacon's Life and Work," *Roger Bacon Essays*, p. 29.
[308]J. H. Bridges, *Opus Majus of Roger Bacon*, I, xxxiv, xxxv.
[309]A. G. Little, *op. cit.*, p. 29.
[310]*Ibid.*, p. 30.
[311]J. H. Bridges, *Bacon's Life and Work*, pp. 36-41.
[312]J. W. Thompson, *The Middle Ages*, p. 787.

literary studies[313] by the enthusiasm they enkindled and the facilities they provided. Also scientific life was reawakened by the publicity his labors received from Dee, Heyden, Allen.[314] And Francis Bacon was probably introduced to Roger's excellence at John Dee's home in August, 1582.[315] However, it was a false appreciation that styled Friar Roger Bacon's *Opus Majus,* the *Encyclopedia* and *Organon*[316] of the thirteenth century, because according to the analysis of a most thoroughgoing and unprejudiced scholar, Roger far outshone Francis.[317] The former attempted a comprehensive system of knowledge along literary and mathematical lines with incontestable results, the latter did not make a single original discovery nor a single application worthy of mention.[318]

Coincident with Francis Bacon's use of Friar Roger's learning, the search for the latter's work continued and the finding of any one of them became an event of more than ordinary importance. Libraries immediately sought to procure them. So, in 1678 a whole series of them, including Cranmer's autographed collection,[319] stolen from some Franciscan friary, was added to the Royal Library of England.

From then on until 1733, as far as records go, Roger's influence remained comparatively dormant. The publication of his *Opus Majus* by Jebb in that year[320] revived interest in him, an interest which was renewed whenever reports of succeeding discoveries of his manuscripts reached educated circles. After that his influence reached

Opus Majus Printed

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[313]J. E. D. de Montmorency, "Roger Bacon," *Cyclopedia of Education* (1919), I, 316.

[314]J. H. Bridges, *Opus Majus of Roger Bacon,* I, xxxv.

[315]W. R. Newbold, *Cipher of Roger Bacon,* pp. 36, 37.

[316]R. Adamson, "Roger Bacon," *Dictionary of National Biography* (New York: Macmillan Company, 1885), II, 377.

[317]E. During, "The Two Bacons," *Open Court Magazine* (1914), p. 468.

[318]E. During, *loc. cit.,* p. 468.

[319]J. M. Stone, *Studies from Court and Cloister,* p. 324.

[320]R. B. Burke, *Opus Majus of Roger Bacon,* I, xiii.

wider circles as the old volumes were put in print and scholars more and more thumbed his pages seeking what was best of medieval thought.

Seventh Centenary

Finally, by the opening of the twentieth century organizations like the British Society of Franciscan Studies broadcasted Roger's ideas to world-wide audiences. In this way modern civilization was prepared for the splendid outburst of recognition that the seventh centenary of his birth witnessed in 1914, when admirers in England, Italy, America, and elsewhere, honored Bacon by commemorative exercises, pageants, and publications. Nor does this interest seem to be waning, if one may judge from the comments made as fragment after fragment of his works appears. Already in 1914 thirty-six books were unquestionably from his hand, while forty-one others were probably or doubtfully his.[321] Since then several more have been brought to light; for example, the Vatican Document,[322] found in 1920. The large number of books, magazines and newspaper articles, references, and special studies dealing wholly or in part with the gifted Friar of Oxford has grown steadily with the years.

Even the radio pays tribute to him. Thus on the evening of May 9, 1936, Roger Bacon formed the subject of the half hour weekly broadcast over Station WGN entitled "Titans of Science" sponsored by Chicago, De Paul, and Northwestern Universities. The dramatization depicted in an appreciative and sympathetic way Roger's experiments with light rays and gunpowder, his trial before Saint Bonaventure with its consequent restrictions, and ended with the bequeathing of his precious books to his trusted students, especially his Cipher manuscript to his protégé, John of London.

Lasting influence like this, based on acknowledged merit, induced one popular authority to enthrone Friar Roger Bacon

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[321] A. G. Little, *Roger Bacon Essays*, Appendix.
[322] W. R. Newbold, *op. cit.*, p. 144.

among the six greatest men in all history.[323] Though different men will make different selections of this kind, in the sacred as well as the profane sciences Roger certainly deserves to be ranked high among the world's exceptional men of all time.

[323]T. L. Davis, *Roger Bacon's Letter*, p. 14.

CHAPTER IX

CONCLUSION

Men have so frequently found fault with Roger Bacon and his efforts that on first sight or superficial consideration he seems to approach or even to sink below mediocrity. But a careful and impartial evaluation of Bacon's work enables one to give at least a favorable explanation in the case of every objection. Thus, for instance, it has been said that his references are hazy and unreliable. Certainly, sometimes they are. But critics forget that no systematized, catalogued libraries staffed by courteous attendants were at his disposal. More than that in his day books were extremely rare. To consult them he could not travel at will, nor freely write for the verification of fact or source. Hence, he often had to repeat a citation as well as he could, a citation read or heard years back with only his memory as guide.

Objections Answered

While admitting Bacon's human frailties, which were exaggerated by his opponents and intensified by the heat of argument but mitigated by his knowledge of the issues at stake, I believe his writings prove that: 1) he was progressive-minded, ever planning better solutions; 2) he was critical and problems stood out clearly before his mind; 3) he was a builder, able to remodel successfully the edifices of others; 4) he was a deep, independent thinker, turning aside from beaten paths which lead to error, and braving the world's scathing denunciations.

He championed freedom of inquiry and discussion not in opposition to the Church, which he loved most dearly, but against certain misunderstanding members who could not follow him. Truth and progress, he thought, spring from a

correct estimate of human authority, followed by a proportionate reliance upon actual experiment to demonstrate and prove theoretical thought, guided all along by as accurate a method as one could devise, and the whole gauged by the standard of its practical utility to man. On these four cardinal points he erected an educational system so admirable for its gradual, concrete manner of imparting knowledge and with its broad lines appearing so perfect and foolproof that to depart from them means fatal excess of some kind or other, such as Ipsedixitism, Pragmatism, shallowness, and arm-chair philosophy.

Cardinal Points

His happy method could not fail to produce unusual fruits, even though it had not crystalized into a stereotyped technique. He was entirely too versatile to be bound by definite rules. His scheme of study presupposed an alert, ingenious, inquisitive mind endowed with uncanny cleverness for investigating and solving at least partly the knotty problems of life or phenomena in nature.

By his efforts Theology became a highly practical, independent science; the study of Sacred Scripture received remarkable principles for regaining and maintaining the genuine text of the Holy Bible; Canon Law tended toward a definite, ecclesiastical code; Sacred Eloquence emerged as a systematic art for winning souls.

Besides absorbing his important positive contributions, Scholastic Philosophy could likewise have employed with profit his combination of authority, theory, and experiment both to preserve itself and later to safeguard its offspring from degeneration.

Philosophy and Linguistics

Orderly, productive language study began with his scientific grammars, and the love he evinced for Latin, Greek, Hebrew, Arabic, and Chaldaic stamped him as the outstanding literary man of his time, who, moreover, drew from these subjects only what elevated and improved the spirit. His philo-

logic accomplishments astonish even a sophisticated twentieth century.

Mathematics found in him perhaps the most sympathetic and devoted friend it ever had and made him in turn the Father of Exact Science, enabling him to devise also such epoch-marking results in Chronology, Geometry, Geography, and to promote the glorious chant of the Catholic liturgy.

Father of Exact Science

An intense love for nature forced him to bow down close to its myriad wonders. Having observed closely he correlated, generalized. Still seeking more information, he vastly improved his facilities for research; and with such instruments aiding his gifted mind, splendid advances followed for medical science in its various forms, for Alchemy, Chemistry, Geology, Zoology, Biology, Optics, Astronomy, and Physics. These, and the various subdivisions of each, look to him as their founder or developer or promoter; and he devised and suggested numerous applications for industry and laboratory research. He took almost every natural science bequeathed by his predecessors, improved upon it notably or strenuously advocated its advancement, reduced and arranged its former materials on a more orderly basis, often faulty it is true, but not without a distinct step of progress. He even introduced to men subjects which were entirely new and blazed a pioneer's trail.

It is true, when we read of his eminent discoveries, striking applications, deeply reasoned conclusions, on the surface they appear simple, matter of fact, just what one would have expected. But in them the story of Columbus's egg is repeated many times over. For no matter how crude, no matter how imperfect his first efforts and models may have been, his was the often faint idea upon which thousands could build, his was the new direction by which thousands could proceed, his was the new method of attack according to which thousands could experiment during all subsequent time. Without his beginnings, progress would certainly have been long delayed.

Importance of the Right Start

It may truthfully be said, therefore, that Roger Bacon was not only one of the most educated men of his age, a veritable human encyclopedia, who mastered the existing fund of knowledge, but that he made distinct and original contributions to well nigh every science and stands out as the outstanding forerunner of modern learning.

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